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EDITORIAL

AGRICULTURAL CONFERENCES IN CEYLON.

THE Tea Research Institute of Ceylon held a conference on March 11 in the Board Room of the Department of Agriculture. The occasion was a memorable one inasmuch as the conference was the first to be held under the auspices of the Institute. The attendance was satisfactory, though it would have been pleasing to note the presence of more Ceylonese planters, and the speakers were followed with keen interest. Papers of a high degree of excellence were delivered by the four research officers of the Institute, by a practical planter and by the consulting engineer of the Institute, and each paper led to interesting discussion. It was apparent to those who were present that the conference was a successful one, and it is hoped it will prove to be the forerunner of many more equally successful gatherings.

It was hinted by the Chairman that there was need for a Tea Research Institute Conference in order to justify the work and policy of the Institute in the eyes of certain planting critics, but it is unnecessary to stress the need for or the benefit to be derived from agricultural conferences in general and one-subject conferences in particular. The explanations, for instance, of work in hand, of its aims, its methods and its possible developments, especially when attention is confined to a single subject like tea,

are always of interest, and it is thought that there is more demand for discussion and questions and answers of a practical nature than for argument of obscure points by specialists. It has also to be remembered that the opinions and ideas of the practical planter may be of great value to the research officer, and that the establishment of a personal touch between the two parties is of great importance. From the foregoing point of view, the Tea Research Conference fulfilled its objects.

The success of the one-subject conference under notice leads one to think that the plan is worthy of extension and that a conference on, for example, the research work on the cultivation and preparation of coconut products that will be undertaken in due course by the officers of the new Coconut Research Scheme will be acceptable and educative. Similarly, a rubber conference, a paddy conference and a conference on village agriculture may be considered. It is not desired, however, that these one-subject conferences should supersede the general agricultural conference which has been held by the Department of Agriculture for the last three years, but it is felt that the question of alternating the larger conference with shorter one-subject conferences is worthy of consideration. The general conference would thus become a biennial instead of an annual meeting. A tentative proposal has already been put forward. It is interesting to note that the Planters' Association and the Ceylon Estates Proprietary Association agreed to the proposal that the larger conference should be biennial and that the Low Country Products Association objected to it on the ground that the agricultural conference was of such value to its members that they preferred it to be of yearly occurrence. The objection to a biennial agricultural conference may be overcome if it is shown that alternate years can be profitably occupied by one-subject conferences. No decision on the point has been made, but in the meantime it is considered expedient to postpone the agricultural conference that should have been held in May of this year until after the arrival of Mr. Stockdale's successor in the post of Director of Agriculture.

ORIGINAL ARTICLES.

THE CULTIVATION OF PADDY (ORYZA SATIVA) IN THE NEIGHBOURHOOD OF PERADENIYA.

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Introduction.—Rice is the staple food of the Island. It is regrettable that paddy cultivation is the least remunerative and consequently the least attractive of the major agricultural industries of the Island from the point of view of the land-owner, owner-cultivator or tenant-cultivator. General improvements are possible in three directions:—

1. Improved cultural methods,
2. Use of higher-yielding selected paddies,
3. Improvements in the economic conditions of the cultivator.

It is not possible to suggest definite improvements to better the lot of the *goiya* or cultivator without a preliminary study of the conditions, requirements and prevalent practices of each locality and without experimental data obtained at each centre. Investigations into the various problems of paddy cultivation overwhelm one with the increasing diversity and complexity of their nature; consequently suggestions for improvements should be made with caution.

It was suggested by the Economic Botanist that the writer might make preliminary enquiries at important centres. The first centre selected was Peradeniya with its outlying villages of Gannoruwa, Meewatura, Héndeniya, Yalagoda, Eriyagama, Bowala and Siyambalapitiya. Enquiries commenced in May, 1928, and were carried on as time permitted. On July 25, 1928, the Food Products Committee of the Board of Agriculture resolved that with the assistance of local sub-committees enquiries should be made into the conditions under which paddy is cultivated in the different districts of the Island; hence future enquiries will be left in the hands of the sub-committees.

Climate.—Peradeniya is situated at an average elevation of 1,550 feet above sea level. "The climate is warm, moist and very equable, the mean average temperature being 76°F. In the early mornings of January and February temperatures around 55°F. are recorded."*

Average number of rainy days and average rainfall by half-monthly periods at Peradeniya for the ten years, 1917-1926.

Month	Rainfall in inches		Number of rainy days	
	1st half	2nd half	1st half	2nd half
January	3·58	1·80	6·3	3·3
February	0·98	0·93	1·9	1·6
March	2·60	2·80	4·5	4·9
April	2·74	3·32	5·3	6·9
May	4·16	2·99	6·8	5·1
June	5·10	5·44	9·0	10·4
July	2·71	5·06	8·1	10·5
August	5·02	3·09	9·5	9·3
September	2·45	5·99	6·2	7·9
October	4·03	8·14	7·2	10·4
November	6·41	6·62	10·7	7·6
December	4·03	3·50	6·3	5·3

The above table shows that rain falls in both monsoons. The north-east monsoon rains proper fall in October-January and the south-west monsoon rains in May-August. The latter half of January-April is the dry season. The annual rainfall averages 93·49 inches and falls on an average of 165 days.

Paddy Soils.—The paddy soils of the Peradeniya district are rather light. Some fields at Gannoruwa receive light alluvial deposits as a result of the more or less annual overflow of the Mahaweli-ganga.

Seasons and Varieties.—The two main seasons are *maha* (long-aged) and *yala* (short-aged). A *meda* or mid-season crop is not cultivated. The principal crop is grown in *maha* when varieties maturing in 6-7 months are grown during the north-east monsoon rains. Cultivation commences in the latter part of August or in September. The *goda-kumburu* or drier fields are sown with a 5-months variety. If the north-east monsoon rains are late, a correspondingly shorter-aged variety is grown. During *yala* only some of the low lying *mada-kumburu* or muddy fields are cultivated with varieties maturing in 3-4 months. Cultivation commences in March-April with the advent of the south-west monsoon.

* *Guide to the Royal Botanic Gardens, Peradeniya* by T. H. Parsons.

The principal varieties grown are as follows:—

Season	Variety	Age	Remarks
Maha	Sudu Hatiel	7 months	Sown on *mada-kumburu*
	Kalu Hatiel	,,	
	Mawi	,,	
	Suduwi	,,	
	Ratawi	6 months	
	Sudumawi	,,	
	Hondarawala	5 months	Sown on *goda-kumburu* and late sowing on *mada-kumburu*
Late maha	Heenati	4 months	
Yala	Heenati	,,	
	Balawi	,,	

Cultivators do not reckon the age of a crop from time of sowing to the time when the crop is actually ready for harvest but to the time they are able to harvest it; hence it is safe to reduce the ages by a fortnight.

Although the area under survey is within a radius of three miles of the Royal Botanic Gardens, yet the cultivation of different varieties of paddy in the different localities testifies to the diversity of requirements and conditions prevalent. For instance, most of the terraced fields at Siyambalapitiya possess only about 8 inches of surface soil; below this is an impermeable lateritic subsoil. The writer was informed that several varieties were tested in the locality but only *Suduwi*, *Maha Hatiel*, and *Ratawi* for *maha* and *Heenati* for *yala* proved suitable. Possibly the suitability and adaptability of the root-systems of these varieties to the existing soil conditions accounted for their success. This would appear to point to a new factor which requires consideration when studying the suitability of a variety or selection to a particular tract.

Irrigation.—The crops are mainly rain-fed but are dependent on regular irrigation from small streams conveying the percolating water from hillsides and underground springs. Water storage facilities do not exist in the locality but a more or less satisfactory and steady stream of water from the surrounding hills can be depended upon. Usually the upper fields are flooded and water is allowed to flow into the lower ones through temporary breaches in the bunds. If the excessive meanderings of the streams were corrected, the embankments strengthened and silt cleared regularly, the frequent damage caused by overflow of water during rains would be minimised to an appreciable degree.

Manures and Manuring.—Systematic manuring in any form is not practised. The fields bordering the high land receive the loppings of overhanging branches. In some parts cultivators may occasionally apply a few bundles of tender branches and leaves of *kekuna* (*Canarium zeylanicum*), dadap (*Erythrina lithosperma*), *Gliricidia maculata*, etc., immediately after the second ploughing. A few cultivators who own roadside fields and those who find accumulated heaps of cattle manure in their compounds and whose fields are not too far away at times apply cattle manure at the rate of about eighty basketsful per acre. One or two cultivators are known to collect dry fish heads from the neighbouring boutiques and apply them to the fields. The above, however, are the exceptions rather than the rule. Artificial manures are not applied, the reason stated being want of ready cash to purchase them. It is very doubtful whether manures would be purchased even if money was available. In defence of the cultivators it may be pleaded with considerable truth that both owner-cultivators and tenant-cultivators are invariably too poor to purchase artificial manures. The landowners who can afford to meet the cost are indifferent and leave the tenant to do his best, but demand a half-share of the produce irrespective of any expenses incurred by the tenant in attempting to increase the yield. The tenant-cultivators do not find it economical to manure the fields as they receive only a half-share of the produce and, further, they cannot expect with any degree of certainty to retain the lease of a field for two or three consecutive years. No valid plea, however, can be brought forward in defence of the cultivator who does not take the trouble to apply farmyard manure or green manure which exist in abundance in the neighbourhood.

Seed and Seed Rates.—Seed-selection is not practised. A few cultivators thresh, as early as possible, the produce of the best-ripened field and reserve it for seed purposes. This seed is stored in the *attuwa* or horizontal shelf over the kitchen fire or in wooden boxes, or it may be packed in gunny bags and stored in a convenient place. Seed is not thoroughly winnowed before storage, the reason stated being that more good grain is exposed; consequently it is attacked by insects and many empties result. Usually cultivators reserve sufficient seed for the next season's sowing. In case a cultivator is obliged to borrow seed-paddy, he has to return the quantity borrowed with 50 per cent. interest in kind at time of harvest. If he has to secure seed from outside his village where he is not well-known, he has to pay cash. At sowing time a bushel of paddy costs about Rs. 3-00 and at harvest about Rs. 2-00. It will be seen that the value of seed-paddy at sowing time is approximately equivalent to the value of the same quantity of paddy plus 50 per cent. as interest at harvest time; hence the interest on seed-paddy charged by villagers is fair.

Cultivation.—About 25 per cent. of the *maha* crop is transplanted. The remainder is broadcasted, and, after about two months, it is thinned out and the vacant spaces are filled with the uprooted seedlings. The *yala* crop, being a short-aged one, is never transplanted. Preparatory tillage consists of the operations described below.

About 7-10 days prior to the first ploughing or *bin-neguma*, breaches in the bunds are repaired and water let in to soak the soil. The village plough (see fig. 6) drawn by a pair of buffaloes (see fig. 4 for yoke) is then brought into use. One pela or $\frac{1}{2}$ acre can be ploughed by a pair of buffaloes in a working day of about $9\frac{1}{4}$ hours. After the first ploughing the fields are flooded in order to decompose the weeds and are kept submerged for a period varying from a week to a month, depending on the state of decomposition of the weeds, the convenience of the cultivators and, above all, the suitability of weather conditions for sowing. The cultivators realise the benefit of thorough decomposition of weeds. It may be of interest to note that experiments conducted by the Department appear to indicate that better results can be obtained by burying green manures late rather than early. The second ploughing or *pitaheluma* or *dehiya* is performed 10-14 days before sowing. This operation is also done with the village plough. About 10-12 *lahas* or $\frac{1}{2}$ - $\frac{3}{4}$ acre can be ploughed by a pair of buffaloes in a day. Ploughing of fields is immediately followed by scraping of bunds with mamoties (see fig. 3) and by plastering them, lopping of overhanging branches along the boundaries and burying them in the fields by trampling under foot. Fields are then flooded to their full capacity.

Immediately the above operations are completed attention has to be paid to the preparation of seed for sowing. The process is as follows. The seed is thoroughly winnowed and soaked overnight in a suitable receptacle for 12-14 hours. If a suitable receptacle is not available, seed is packed in a gunny bag and lowered into a well or submerged in standing water in the field. The next morning water is drained off and along with it any light grains found floating. The soaked seed is heaped on leaves of plantain (*Musa* sp.), *alakola* (*Alocasia*) or arecanut (*Areca catechu*) and placed on the ground in a dark cool place inside the house. The heap is then covered with more leaves and gunny bags or mats and weights are placed on it. The seeds germinate and are ready for sowing in 6-7 days. If it is desired to hasten germination, more covering and greater weights are applied in order to raise the temperature in the heap; if germination has to be delayed, lighter covering and fewer weights are provided. If, after seed is ready for sowing, unforeseen circumstances delay the process, the weights and coverings are removed and air is permitted to play upon the heap. This checks the speed of development of the sprouted seed to an appreciable degree but does not impair its

vitality. The heap is never broken up and spread out as it is believed that many radicles would be damaged in the process and such damaged seeds dry quickly. No harm is done, however, if the radicles are so damaged just before sowing.

The third ploughing or *madaheiya* is done 2-3 days prior to sowing. This operation consists in ploughing the fields a third time and levelling them roughly by turning the plough on its side and fixing a temporary handle with which to guide the improvised leveller. The operation of levelling is known as *madaedduma*. In case a part of the field has been silted and it is necessary to draw a large quantity of mud from that part and spread it evenly all over, the large levelling board or *porulalla* (see fig. 5) drawn by a pair of buffaloes is used. This operation is known as *paledduma*. In case only the third ploughing and *madaedduma* is necessary a pair of buffaloes can work 1 - 1½ pelas or ½ - ¾ acre per day. After levelling ½-1 inch of water is left in the field before the final levelling or *goygauma* is done in the morning prior to sowing. Hand levelling boards (see fig. 1) are used in levelling the fields and opening up shallow surface drains in a fan pattern which converge on a point at one end of the field. Each block thus separated by surface drains is given a final levelling, the cultivator walking backward in order to cover his foot-prints. The fields are then completely drained.

Sowing.—Handfuls of sprouted seed are worked between the palms. This causes the seeds to separate to an appreciable extent with their radicles damaged as little as possible. Seed is then scattered in the fields in a remarkably even manner. One man can sow a little over 2 acres per day. The explanation offered for the non-establishment of seedlings along the shallow drainage channels is that the seeds become too deeply buried in the fine mud.

Irrigation.—Water is not let into the newly-sown fields until the surface shows faint signs of cracking. In *godakumburu* or drier fields water has to be let in after an interval of about three days. In *madakumburu* or muddy fields it would not be necessary for 6-7 days after sowing. At the first irrigation, 1 inch of water is permitted to flood the fields evenly and after an interval of twenty-four hours is drained off in order to minimise the damage done by land crabs and the possibility of some of the seedlings being drowned. Again, after an interval of 2-5 days which depends on the nature of the fields, an inch of water is let in when faint signs of cracking are noticed. In case crabs cause noticeable damage the fields are once more drained after a day or two and allowed to dry as before prior to having the third and final irrigation. After this the fields are not dried during the growing period. By now the seedlings are well developed and are rarely damaged by crabs. After the second irrigation, if crab attack is

not noticeable, water is retained in the fields. As the plants grow the level of water is raised until it reaches about 4 - 6 inches. Fields are finally drained when the grain is in an advanced milk stage and culms show signs of yellowing.

Transplanting.—When fields are transplanted with seedlings raised in a separate nursery, 1½-2 months old seedlings depending on their growth are used. If nurseries have been sown thickly or on poor soil, seedlings are not transplanted until they are about two months old; but, when sown thinly and if they are well developed, 1½-months old seedlings are transplanted. The reason stated for not transplanting month-old seedlings is that such seedlings are delicate and are more liable to be damaged on uprooting and to suffer a setback. Fields are not completely drained before transplanting as ½ - 1 inch of standing water facilitates the operation. Some cultivators suggest that, when transplanting is done in a flooded field, the clay in suspension settles down and affords a firmer seed-bed to the seedlings. The nurseries are flooded overnight and women usually pull up the seedlings, wash the soil from the roots, and tie the plants into bundles of a size conveniently handled in transplanting. Before transplanting the tops of the bundles are broken off with a twist of the hand, leaving about 6-8 inches or even 12 inches of stalk above ground level. The bundles are held in one hand and with the other three or four seedlings at a time are selected with the fingers at the roots and with a single thrust are set in the mud with a slight inclination to windward. Each bunch is set 2-4 inches apart in the rows. The women move backward across the field. Topping the seedlings and planting them at an angle are regarded as precautionary measures to minimise the chances of plants being blown down. All fields are drained the same day they are transplanted in order to provide a firm seed-bed. After about three days 1 inch of water is let in. Subsequent treatment is similar to that given to broadcasted fields.

Weeds and Weeding.—The rapidity of subsequent weed growth depends on the cultivation given and the time allowed for decomposition of weeds. About two months after sowing broadcasted fields are weeded once at the time they are thinned out and the vacancies are filled. The cost is about Rs. 10-00 per acre. Transplanted fields are not weeded. The weeds commonly met with are *Fimbristylis milacea* (*kudumatta*,) an aquatic weed which is by far the most troublesome, *Cyperus flavidus* and *Cyperus pilosus* (*thun hiriya pan*).

Harvesting and Stacking.—Harvesting is usually done by men using sickles (see fig. 2). About 4-5 inches of stubble is left. In muddy fields a little over 6 inches of stubble may be left. Immediately paddy is harvested in wet fields, women spread the plants on the nearest bunds to dry. On dry fields they are allowed

to remain in the field until evening when they are carried to the *kamatha* or threshing floor. A *kamatha* is used jointly by several cultivators. Those whose fields are harvested first get their produce threshed first. The harvested paddy may be carried to the *kamatha* the same day or the day after, depending on the storage space, and stacked in loose bundles. The stacks may be of two kinds:

1. *Rana kanda*, i.e., the loose sheaves stacked in a row with the earheads in one direction. This is done only if threshing is possible in a few days or no rain is anticipated. Seed paddy is usually reserved from the threshings of this stack.

2. *Kolegahanawa*, i.e., the loose sheaves are stacked in a circular arrangement with the earheads towards the centre, the topmost layer within easy reach and tapering to a point. The top layer is covered over with straw, if available, or with a few sheaves. If the paddy has not been well dried and threshing is delayed, fermentation takes place and destroys the viability of the seed. Unless another paddy crop follows, the fields are not ploughed soon after harvest although it is possible to do so in most cases.

Threshing.—Threshing is usually done in the cool of the night by buffaloes which are driven in a circular path over a heap of the paddy. If harvesting operations are not interfered with and if the *kamatha* is situated in a shady place or if wet weather is anticipated, threshing may take place during day and night. Three or four men with a pair of buffaloes and a boy to drive the latter can thresh the produce of $\frac{1}{2}$-acre or one *pela* in a night. Grain is lightly winnowed and is then ready for transport.

Yield.—The fertility of individual fields is very variable. Long-aged varieties yield more than short-aged varieties. The crop grown during *maha* yields about 30-35 bushels of grain per acre and 800-900 bundles of straw. Each bundle weighs about $1\frac{1}{2}$ lbs. Some cultivators claim yields as high as 60-75 bushels per acre but the accuracy of these figures is questionable. The *yala* crop yields about 15-18 bushels of grain and about 600 bundles of straw. A rough average yield per acre for the entire tract approximates to about 30 bushels in *maha* and 15 bushels in *yala*. The value of a bushel of paddy soon after harvest is about Rs. 2-00 and later in the season Rs. 2-50 to Rs. 3-00. The straw is used for thatching roofs and for feeding draught cattle. The value of 100 bundles is about Re. 1-00. Very wide tracts of paddy land do not exist in any of the localities surveyed. Both grain and straw are rarely sold outside the village as the output is required for individual and local consumption.

Pests and Diseases.—(a) Pests. 1. *Paratelphusa* (*Oziotelphusa*) *hydrodromus* Herbst. The small land crabs commonly met with in paddy fields do considerable damage by breaching the

bunds of terraced fields and make retention of water in such fields very difficult. In broadcasted fields the seed rate is heavy, hence the damage done by crabs is not serious but in transplanted fields appreciable damage may be caused. In a certain locality which is favoured with a ready supply of water and in which the fields are terraced and are afforded rapid drainage, the cultivators drain the fields nightly till the seedlings are about 10-12 days old. The reason stated is that crabs feed mostly at night and move more freely in water. No direct control measures are adopted except that permission is granted occasionally to Tamil coolies to capture the crabs for eating. 2. *Leptocoriza varicornis* (paddy fly). When this pest appears in large numbers the *yakdessa* or *charmer-away-of-paddy-fly* is sent for. His incantations accompanied by the blowing of a shell horn are supposed to minimise the damage that would otherwise have been caused. One cultivator informed the writer that when the *goyam messo* provoked him by appearing in large numbers and persisting in its attack he placed at night around the affected fields several lighted torches made of dry coconut branches and drew a rope lightly over the plants. The disturbed insects were attracted by the lights and they flew straight into them and were burnt. When questioned why this excellent practice was not carried out every season before damage was caused by the fly, the cultivator replied that he used the method described only when *taraha giyama*, i.e., when provoked. 3. Rats. About four different types of rats are known to cause damage to paddy. Preventive or remedial measures are not adopted. Occasionally Tamil coolies come round after the fields are harvested and capture the rats for food by digging or smoking them out of their burrows. 4. Birds. Mostly *munias (Uroluncha striata striata*) come in flocks and cause considerable loss by feeding on the mature grain. Field alarms are improvised and boys and girls are employed to scare the birds. 5. Cattle. Fields are not fenced. Owners tie up their cattle when a crop is growing. Should cattle belonging to fellow-villagers stray and cause damage no claim is made, but, if they belong to outsiders, the owners have to pay the damage assessed by the local headman before removing the animals. Persistent damage caused by negligence of even fellow-villagers is resented and action similar to that employed against outsiders may be taken.

Serious notice is not taken of stem-borers and other minor pests. Grain when not thoroughly sun-dried before storing is attacked by two pests. 1. *Sitotroga cereallela* (paddy moth). Cultivators believe that this pest lays its eggs on the grain while in the field and that when in storage the eggs hatch out. They believe that a second brood does not develop as the moths find conditions unfavourable and do not lay eggs. The experience of the Department indicates that it is very probable that eggs are laid in the field and that subsequent broods develop while the

paddy is in the store. The life cycle of this pest occupies four weeks. Paddies stored for four and five months have showed moth infestation to a marked degree. It is also the experience of Herrick in America and Fletcher in India that this pest breeds in the store. 2. *Calandra Oryzae* (paddy weevil) is believed to breed in stored grain. Seed stored in the *attuwa* or horizontal shelf over the kitchen fire has been found to be very little, if at all, attacked by either moth or weevil.

(b) Diseases. Seedlings may be attacked by *Sclerotium Oryzae* and *Piricularia Oryzae* may attack both seedlings and mature plants. *Rhizoctonia Solani* is also suspected to attack seedlings. On the whole, fungus diseases are not serious although in certain unfavourable seasons considerable damage may be caused to young seedlings.

Rotation.—Paddy is not rotated with any other crop. In some parts cowpeas are grown on the bunds after the paddy is grown. Even if fields are cropped for only one season, a green manure crop is not grown in the off season.

Labour.—All cultural and harvesting operations are done on a communal or co-operative basis. The necessary human and animal labour is secured to complete each cultivator's area in a single working day. If a cultivator requisitions the assistance of ten others, he turns out to work for the others for ten days. Likewise, should he borrow buffaloes he lends his own animals. In case he does not own buffaloes he hires them at the rate of Rs. 2 per pair for cultural operations and Re. 1 per pair for threshing.

If labour is paid for, as it very rarely is, the following daily rates are current: for men 75 cents, for women 40 cents, for boys 35 cents. Meals are provided by the employer, both to co-operative workers and hired labourers.

Live Stock.—Most of the owner-cultivators own at least a single buffalo, if not a pair. Landowners own more than a pair. The animals are castrated. When they are about three and a half years old they are employed in threshing operations. Only animals of over four years of age are employed in cultural operations. They are capable of twelve to fifteen years of service after which they are permitted to roam about and die a natural death. The religious susceptibilities of the people will not permit them to sell the animals to the butcher. Bullocks are not employed for cultural operations. Usually every cultivator owns at least one or two cows of local breed. Both cattle and buffaloes suffer from want of proper pasture. They are neither stall-fed nor housed at night, but occasionally a few jak (*Artocarpus integrifolia*) fruits or plantain (*Musa* sp.) stems may be chopped up and fed to them. The former is supposed to increase the milk yield of cows. The value of a pair of buffaloes varies from Rs. 80-00 to Rs. 150-00, that of cows from Rs. 20-00 when not in milk to Rs. 50-00 when in milk. Hoof-and-mouth disease may be serious at times.

Cost of Implements.—The implements used locally can be purchased at the following rates: plough Rs. 5-00, yoke Re. 1-50, large levelling board Rs. 5-00, small levelling board Re. 1-00, mamoty (Sinhalese) Rs. 2-00, sickle 50 cents.

Land Measure.—10 laha's sowing extent = 1 pela's sowing extent.

2 pela's sowing extent = 1 acre's sowing extent.

2 acre's sowing extent = 1 amunam's sowing extent.

Grain Measure.—10 laha's = 28 heaped measures = 32 cut measures =1 bushel.

Economic Conditions.—The majority of cultivators have little or no ready cash in hand and no source of obtaining loans except at exorbitant rates of interest. The Afghan money-lender charges 50 per cent. interest and forces the borrower to sign an "on demand" pronote for Rs. 250-00 for any sum actually borrowed under Rs. 100-00. If the sum borrowed is over Rs. 100-00 and below Rs. 250-00 two pronotes each to the value of Rs. 250-00 have to be signed. The system is that the borrower has to sign for at least double the amount actually borrowed. Repayment has to be made within an year by proportionate monthly instalments. Further, a surety who happens to be one of the Afghan's customers has to guarantee payment. The chetty money-lender charges the following rates of interest: for Rs. 300-00 and under 25 per cent., for Rs. 300-00 to Rs. 500-00, 20 per cent., for Rs. 500-00 and above 15 per cent. Repayment of any sum under Rs. 250-00 must be guaranteed by a surety. For sums above Rs. 250-00 either jewellery must be mortgaged or land hypothecated. Payment of instalments can be arranged in a satisfactory manner but interest for the full period is deducted from the principal before the sum is handed over. The coast-moor boutique-keeper gives credit without security for purchases made from his boutique. He, however, charges higher rates for credit purchases. The scheme of charges is as follows. If the total value of the goods purchased is not high, about 5 per cent. extra is charged on each item; if it amounts to a fairly high figure $2\frac{1}{2}$-3 per cent. more is charged. As far as the difference between the cash and credit prices goes, the rates charged compare favourably with those charged by the larger firms.

None of the areas is served by co-operative credit societies except that most of the villagers of Gannoruwa work as daily-paid labourers in the Department of Agriculture and are members of the Royal Botanic Gardens Co-operative Credit Society.

During the period between sowing and harvest and between harvest and sowing of the next crop most of the men and women work as daily-paid labourers on neighbouring estates.

Tenancy Conditions.—Roughly, about 75 per cent. of the fields are cultivated by tenant-cultivators and the rest by owner-cultivators. Most of the fields are endowed to the *Dalada Maligawa* (Temple of the Tooth Relic), the *Maha Dewale* and local Buddhist temples. A fair extent is owned by private landowners, some of whom are not local residents.

The average holding of a tenant-cultivator varies from 1 - 1½ *pelas*, i.e., ½ - ¾ acre. Tenants of temple land pay no rents, but in lieu they perform *rajakariya* (compulsory service) during the annual *Esala Perahera*, and also pay their respects annually to the trustees of the temples, carrying with them a box of sweetmeats, betel leaves, etc., in accordance with time-honoured custom. In case they are unable to perform *rajakariya* in person, they provide the necessary labour or pay the cost of such labour. Failure to meet these requirements would result in legal action for recovery of costs and in loss of tenancy. Tenancies are given up only when the fertility of the soil deteriorates badly. On the whole the tenants do not suffer hardships but much depends on the individual who holds the office of trustee. Some tenants of temple land sub-let to other tenant-cultivators on the usual exacting terms that private landowners demand from their tenant-cultivators.

Tenancy conditions under private landowners are onerous. All leases are held at the will and pleasure of the landowner and a lease may terminate at the conclusion of the season. To obtain permission to cultivate a block of paddy land a preliminary fee known as *madaran* or land tax has to be paid. The tax varies from Rs. 5-00 to Rs. 10-00 for a holding of an acre or under and Rs. 20-00 to Rs. 25-00 for an *amunam*. *Madaran* is supposed to cover permission to cultivate during both seasons but complaints have been made that the fee has been levied each season. During the period of tenancy the tenants are expected to assist the landowner at their social and religious festivities and render such general help as may be needed. On occasions when such work is performed by tenants, their meals are provided free. If landowners are displeased, loss of tenancy is the inevitable result. Several complaints have been made of instances where the landowner, not being able to summon a tenant who happened to be temporarily away from home, secured the services of another villager and in return granted to the latter the lease held by the absent tenant, the transfer to take effect from the next season. Tenant-cultivators of land belonging to either temples or private landowners do not receive any assistance from the trustees or landlords. They have to secure their own implements, buffaloes and seed-paddy. If seed-paddy has to be procured, it is customary to

obtain it from the landowners and to return it in kind with 50 per cent. interest after harvest. As has already been pointed out, the rate of interest is fair. If the usual operations of thinning out, filling in gaps and weeding once are not carried out, a more painstaking tenant may be given the fields for the next season.

In half-share tenancies the gross produce is divided on the *kamatha* or threshing floor as follows: 1. The quantity of seed-paddy sown plus 50 per cent. as interest, irrespective of from whence obtained, is set apart. 2. *Akkiyala* or the share of *the-charmer-away-of-paddy-fly*, if his services have been requisitioned, is next set apart at the rate of 1 *laha* (equivalent to 1/10 bushel or 3·2 measures) for each separate block cultivated by each cultivator. 3. If the absentee landowner sends his *gankaraya* to watch his interests at threshing and division of produce, this individual has to be fed and paid one bushel of paddy for each night he happens to be on duty. 4. After deducting the above items the balance of grain and total output of straw are divided equally between the landowner and the cultivator. In some parts the cultivator gets all the straw. Some of the more exacting landowners expect the tenants to deliver their (the landowner's) share at their places of residence.

Improvements Suggested.—As a result of this preliminary enquiry certain general means of improving the cultivation of paddy may be suggested, for example, the greatly extended use of green manures, particularly on land cropped twice yearly, proper storage and use of cattle manure and probably also of steamed bonemeal which has already given promising results at Peradeniya, growing of tested pure-line selections of paddy and the extension of the common but not universal practices of transplanting and particularly of weeding, the regular clearing of silt from *elas* and irrigation channels and the correction, where possible, of the unnecessary meanderings of their courses. For the preparation of a cheaper and better puddle following the first ploughing, the Burmese harrow (see fig. 7) introduced by the Economic Botanist may be recommended. A Burmese harrow can be constructed by a village carpenter at a cost of Rs. 4-50 or less, exclusive of the cost of wood.

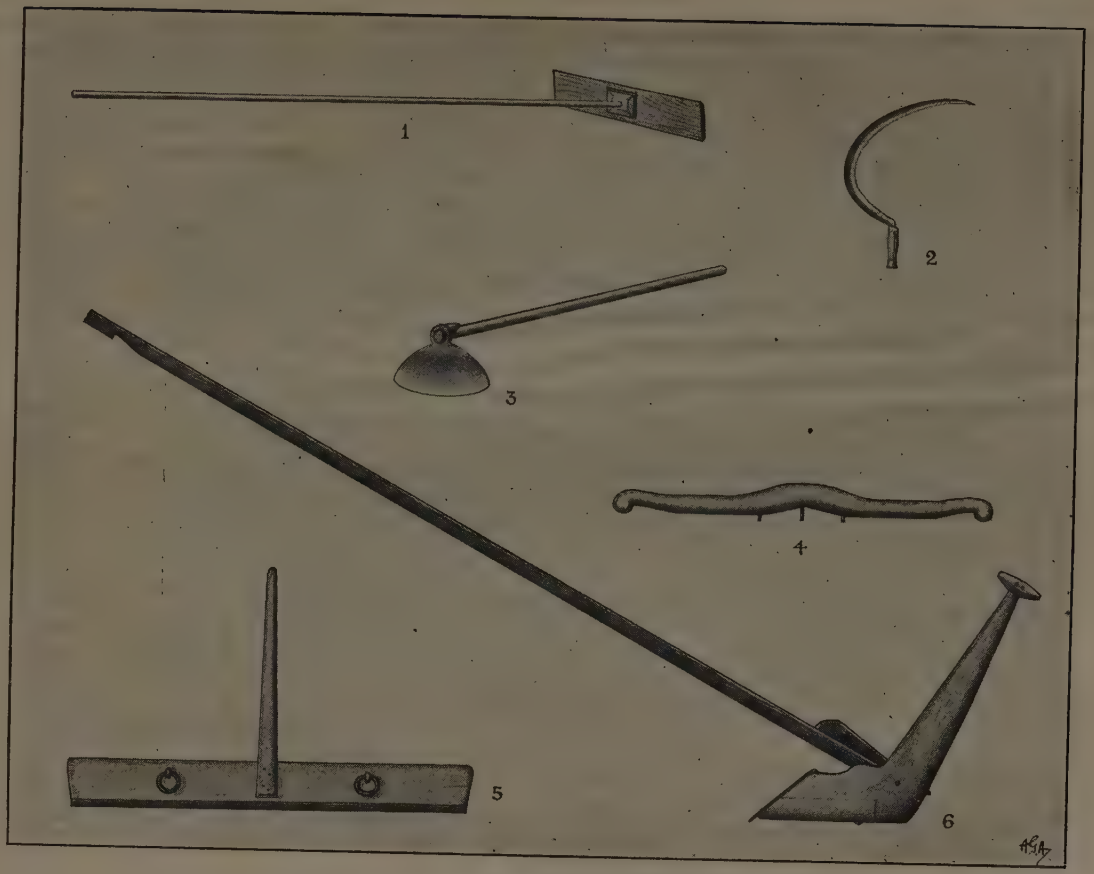
It is to be regretted that no practical methods of controlling insect and rodent pests have yet been discovered. Isolated blocks of fields flowering earlier or later than the majority of fields of a tract will attract all the paddy flies and the damage caused to these

will be considerable. Large areas of paddy should be sown so as to flower at the same time in order to spread the damage over as many fields as possible and permit the minimum possible period during which the pest can feed on the paddy crop. Occasional thorough sun-drying of paddy which has to be stored for a considerable time would minimise the attack of the grain moth.

Tenancy conditions are open to obvious improvements. For example, most tenants would prefer to have land on long lease and preferably on a fixed rental payable after harvest. It is doubtful whether this would meet with the approval of landowners who usually require a large stock of paddy for their consumption and for feeding their dependents; but rent could be paid in kind. Cultivators should be members of a co-operative credit society as it would enable them to obtain cheap credit and also manures, implements and better seed at cheaper rates.

If *madaran* tax is utilised for the supply of green manure, farmyard manure or steamed bonemeal, the accruing results would be of immediate and ultimate benefit, both to the landowners and their tenant-cultivators. This would make paddy cultivation more attractive and less unremunerative than it is. Landowners should appreciate the onerous nature of paddy cultivation and should assist their tenant-cultivators. Constant change of tenancy is the greatest obstacle to any permanent improvements being effected.

In conclusion, the writer wishes to offer his sincere thanks to Mr. L. Lord, the Economic Botanist, for valuable suggestions and help in the compilation of this article.



Indigenous implements used in paddy cultivation.

Fig. 7—Burmese harrow.

CHEMICAL NOTES (4).

ANALYSIS OF ANIMAL ASH.

A sample of animal ash from the municipal incinerator, Colombo, was recently forwarded to this laboratory for analysis and report as to its value as a manure. The sample consisted for the greater part of partially-burnt bones in addition to small amounts of partially-burnt muscular tissue, ash and sand. The sample on receipt was thoroughly crushed and sieved through a 1 m.m. sieve, and a representative portion was subjected to analysis. The analysis is shown in the following table:—

ANALYSIS OF ANIMAL ASH.

	In material as received %	In material at 100°C. %
Moisture ...	4·31	—
Nitrogen ...	2·37	2·47
Potash ...	2·82	2·95
Phosphoric acid ...	19·22	20·14
Lime ...	26·41	27·66

It will be noted that the composition of the sample of animal ash analysed is, as is to be expected, not unlike that of bonemeal. Thus it contains about 20% phosphoric acid and 2·5% nitrogen as against 22% phosphoric acid and 3% nitrogen in bonemeal. In addition the ash has a potash content of nearly 3% and over 25% lime, some of which is in the free state.

Based on present-day market prices of manures, the animal ash is worth over Rs. 100-00 per ton at site. It could very usefully replace basic slag or steamed bonemeal in manure mixtures. It is learnt that from 100 to 150 tons of the ash are available for sale yearly.—A.W.R.J.

CONTRIBUTIONS FROM THE RUBBER RESEARCH SCHEME, CEYLON.

CEYLON RUBBER RESEARCH COMMITTEE.

REPORT ON THE POSSIBILITY OF LATEX BECOMING CONTAMINATED WITH BORDEAUX MIXTURE AS A RESULT OF SPRAYING OPERATIONS.

PREVIOUS investigations (Quarterly Circular No. 4, 1926) have shown that Bordeaux mixture in latex causes the raw rubber to become tacky on keeping and the vulcanised rubber to perish quickly. Although great care is taken on estates to spray only the crowns of trees there is a risk of heavy rains washing the Bordeaux mixture on to the tapping cuts (Quarterly Circular No. 2, 1927). It is stated that in Southern India where spraying operations are carried out on an extensive scale there is no instance of the rubber becoming tacky. On the other hand a trace of Bordeaux mixture, sufficient to cause serious deterioration in the vulcanised product, would not be detected by the appearance of the raw rubber unless it had been kept for some considerable time.

At the request of the Ceylon Committee five samples of machine-dried crepe were accordingly obtained from Southern India by Mr. Bertrand in order that the question might be further investigated. The only information supplied concerning their preparation was that they were "made from latex from a field which is being sprayed with Bordeaux mixture" and that "the rubber sent was from blocks being tapped *at the time of spraying*. No rain fell during the time. Age of trees 21 years. The rubber was machine-dried."

The samples were forwarded to the Imperial Institute for examination, where the raw rubber was submitted to plasticity tests and the vulcanised product to artificial ageing tests. Details of the results are given below, from which it will be seen that the keeping properties are satisfactory in all cases. It should be noted however, that the samples were prepared during fine weather when there was the least risk of Bordeaux mixture reaching the tapping cut.

Although in no case has it been established that spraying the crowns of the trees with Bordeaux mixture either in Ceylon or in Southern India introduces sufficient copper into the latex to cause marked deterioration of the raw or vulcanised rubber, it cannot be too strongly emphasised that its use requires the greatest care.

(A) PLASTICITY TESTS.

Sample No.	Raw Rubber.		Masticated Rubber.	
	D30*	Time of Masti-cation.	D30*	Ev+
	(mm./100)	(mins.)	(mm./100)	(ccs.).
1327	140	21½	76	11·7
1328	144	22½	73	13·8
1329	139	22	71	14·1
1330	146	22½	73	13·7
1331	145	24	74	13·5

*D30= Thickness (in hundredths of a millimetre) of sphere 0·4 grams in weight after pressing in parallel plate plastimeter at 100°C for 30 minutes.

+Ev= Volume in ccs. extruded in 1 hour at 90°C.

These results show that the samples, although more plastic than air-dried crepe, are not definitely more plastic than average machine-dried crepe, and much less plastic than the set of samples previously examined which were prepared from latex to which small quantities of Bordeaux mixture were added.

(B) ARTIFICIAL AGEING TESTS.

The samples were vulcanised in a rubber-sulphur mixing (90·10) at 148°C and submitted to artificial ageing tests in a current of air at 70°C.

Sample No.	Time of vulcanisation.	Period of ageing.	Tensile Strength.	Elongation	
				At Break.	At load of 1·04 kgs./sq.mm.
	(mins.)	(hrs.)	(lbs./sq. in.)	(per cent.)	(per cent.)
1327	120	nil	1870	908	850
		48	2130	827	755
		96	1460	736	735
		144	990	583	675
1328	114	nil	1810	935	877
		48	2250	873	786
		96	1920	784	727
		144	890	564	723
1329	116	nil	1830	913	870
		48	2100	876	806
		96	1910	802	741
		144	840	581	700
1330	125	nil	1840	885	846
		48	2120	833	754
		96	1850	767	706
		144	370	412	—
1331	125	nil	1990	907	854
		48	2050	818	752
		96	1830	774	709
		144	400	426	—

These samples vulcanise somewhat more slowly than machine-dried crepes from a number of Ceylon estates. The artificial ageing properties are similar to those usually found for crepe.

It may be concluded from this investigation that none of the samples contains even a trace of Bordeaux mixture.

Imperial Institute,
London, S.W.
June, 1928.

REPORT ON THE DETERMINATION OF THE PLASTICITY OF RUBBER.

IT is generally agreed that the consistency of raw and masticated rubber is of considerable importance and requires detailed study, but it is only recently that definite methods of measurement have been devised. Previous to the introduction of these tests a technologist pulled and pressed a piece of rubber between his fingers and described it as hard, soft, plastic, tough, nervy, weak, short, etc., according to his conception of the meaning of the terms and the impression he had formed of the material under examination. No investigation is likely to be successful which lays its foundation on these shifting sands of vague terms and personal opinions. Attempts have therefore been made by several investigators to find a more satisfactory basis of study.

Two main types of test have now been developed, viz:—an extrusion and a compression test. In the extrusion test (introduced by Marzetti) the rubber is deformed by forcing it at a definite temperature and pressure through a small orifice. The rate at which the rubber flows is regarded as a messure of plasticity. In the compression test introduced by Ira Williams a small ball of rubber is pressed by a weight and the rate at which the rubber decreases in thickness is regarded as a measure of plasticity. Each of these methods is used by different manufacturers who state that the results obtained agree with works experience. Neither method can be regarded as wholly satisfactory however because the results are largely dependent upon conditions. This is particularly noticeable in the case of extrusion tests as shown in the following paragraphs:—

Extrusion Tests.—An experiment was carried out at the Imperial Institute in which a series of samples of crepe was extruded under high and low pressures through the same orifice. The following are the results obtained:—

Sample No.	Rate of Extrusion.	
	Load 165 lbs./sq. in.	Load 1,000 lbs./sq. in.
1380	25·6	28·6
1381	23·8	27·5
1382	15·4	26·6
1383	14·9	24·8
1384	14·5	24·8

There is considerable difference between the rates of extrusion of sample 1380-1 and of samples 1382-4 at the low loads but not at the high loads.

Other experiments show that the relation between the results of tests on different samples not only changes with the loads but also with the dimensions of the orifice.

The effect of load on rate of extrusion was studied in detail at the Imperial Institute for a large number of samples of masticated rubber. It was found that the character of the flow altered with the load applied. At low loads evidence was obtained which suggested that the flow of the rubber was not wholly telescopic, i.e., the flow measured was a combination of plastic and other types of flow. At higher loads there was definite evidence of slipping at the walls of the orifice. The differences in the character of the flow as the load was increased was confirmed by the change in the appearance of the extruded "worm." At the lowest load tried the "worm" was always smooth. On increasing the load it became corrugated. At higher loads still it became smooth again but developed a spiral twist which was very marked at the highest loads tried.

When the diameter of the orifice was considerably reduced and its length increased the mathematical relation between load and rate of extrusion was different from that obtained previously. There was no definite evidence of slipping at the walls of the orifice and it is considered that the flow was more in accord with true plastic flow. This question is still under consideration and it is hoped to deal with it in a later publication.

Although rate of extrusion depends upon too many factors to form a sound basis for the comparison of plasticities, there is no doubt that as a rough test it is a valuable help. For example no difficulty is experienced in following the increase in plasticity of rubber during mastication, and at the Imperial Institute advantage is taken of this fact to study the effect of mastication on rubber.

It is considered that the plasticity of the unmasticated rubber is of little practical importance compared with the rate at which the plasticity of the rubber increases during mastication. The rubber is therefore ground through laboratory rolls for different times and the number of grindings required to reduce the rubber to a condition in which it extrudes at a fixed rate is determined. Small differences between different rubbers cannot be detected with certainty by this method, but if attention is concentrated on large differences there is little doubt that the tests are of considerable value.

Compression Tests.—Concurrently with the investigation of the fundamental principles underlying the extrusion test, a similar study has been made of the compression test. Considerable progress has been made enabling these tests to be placed on a much sounder basis than previously.

The simplest form of the compression test is that introduced by Van Rossem and Van der Meyden, the rubber under test being placed on a raised platform so that there is a constant area of rubber in contact with the weight, instead of an area which increases as the thickness decreases. Under these conditions it was found at the Imperial Institute that there is a simple and accurate relation between the thickness of the rubber and the rate at which it decreases in thickness. This relation is expressed by the equation

$$\frac{1}{S_2^2} - \frac{1}{S_1^2} = Kt.$$

where S_1 and S_2 represent initial and final thickness over the time interval t. The value of K depends upon the plasticity of the rubber and the conditions of the experiment, but it is constant throughout an experiment.

The question has also been studied theoretically with a view to obtaining measurements in absolute units, and at the request of the Imperial Institute considerable help has been given by the staff of the National Physical Laboratory. The problem is comparatively simple for a viscous liquid but is much more complex for a plastic solid, and further work on fundamental principles is necessary. It is hoped to carry out this work when opportunity arises.

The results already obtained however are of considerable practical value because they enable the relative plasticities of different rubbers to be obtained in a quick test with simple apparatus in units which are theoretically proportional to the rate of extrusion and therefore very sensitive to changes in plasticity. The test has the further advantage that different laboratories in different parts of the world should have no difficulty in obtaining the same results with rubber of the same plasticity. In the case of extrusion tests this would be difficult to achieve. It is considered premature however to put forward definite suggestions at present as the work is still proceeding, practical details require consideration, and further improvements may shortly be made.

Imperial Institute,
London, S.W., 7.
February, 1929.

REPORT ON THE EFFECT OF DILUTING LATEX ON THE PLASTICITY OF CREPE.

THE results of the examination of a previous series of samples prepared in Ceylon at the request of the London Committee indicated that crepe prepared from diluted latex is more plastic than that from undiluted latex, as determined by tests on the raw rubber. Tests on the masticated rubber however did not show a regular change with dilution (Bulletin No. 49).

A further set of samples has now been examined consisting of crepe prepared from undiluted latex (34·7 per cent. dry rubber) and from the same latex diluted to 30, 20, 10 and 5 per cent. dry rubber. As in the case of the previous set no bisulphite was added and the amount of acetic acid used for coagulation was adjusted to the dilution of the latex.

The following are the results of plasticity tests:—

TABLE I.

Plasticity tests.

Sample No.	Concentration of latex.	Raw rubber D_{30}+	Number of grindings through laboratory rolls required to reduce rubber to a standard plasticity.*
	per cent. dry rubber.	mms./100	
1380	35	166	64
1381	30	168	60
1382	20	163	60
1383	10	160	60
1384	5	154	55

* The standard of plasticity adopted is a rate of extrusion of 10 cc. per minute under load of 1000 lb./sq. in. at 85°C.

+D_{30} = Thickness (in hundredths of a millimetre) of sphere 0·4 grams in weight after pressing in plasticity press at 100°C for 30 minutes.

The results of tests on the raw rubber are very similar to those given by the previous set of samples. On the whole the more dilute the latex the more plastic is the rubber obtained from it.

Experiments in Java by Dr. de Vries indicate that there is little difference in the plasticity of crepe from diluted and undiluted latex when first prepared but that the plasticity of the crepe from diluted latex increases more than that from undiluted latex on keeping for 12 months in the tropics (Archief voor de Rubber-

cultuur April 1928, p. 259). The results obtained in Java are consistent with those found at the Imperial Institute where the samples are tested six months after arrival, i.e., about eight months after preparation.

The results obtained at the Central Rubber Station, Java, and the Imperial Institute are compared in the following table:—

TABLE II.

Ceylon Rubber Research Scheme Tests in London 8 months after preparation.						Central Rubber Station Tests in Java*		
Sample No.	Concentration of latex.	D_{30}	Sample No.	Concentration of latex.	D_{30}	D_{30}		
						Dilution	Fresh rubber.	Rubber one year old.
	per cent. dry rubber.	mm./100		per cent. dry rubber.	mm./100		mm./100	mm./100
1355	35	167	1380	35	166	1·1	1·55	1·43
1356	30	165	1381	30	168	1·4	1·55	1·38
1357	20	160	1382	20	163	1·9	1·51	1·31
1358	10	159	1383	10	160	1·49	1·48	1·20
1359	5	156	1384	5	154			

* See Transactions of the Institution of the Rubber Industry, III 1927, p. 293.

All these experiments support the view that a few months after preparation raw crepe from diluted latex is softer than that from the undiluted latex.

Mastication experiments on laboratory mixing rolls indicate however that in the case of both series of crepes from Ceylon the change in plasticity of the raw rubber is of little practical importance. For example in the previous series of experiments carried out in London (Bulletin 49) in which the rubber was masticated until it had consumed a fixed amount of power, the differences in the rate of extrusion were irregular and small. In the tests on the present series (see Table I) the samples were ground through the rolls a fixed number of times and the amount of mastication to produce a fixed rate of extrusion calculated. The differences were again small, but the crepe from the very dilute latex required less mastification than that from undiluted latex.

It seems probable from these experiments that several months after preparation, raw crepe from very dilute latex would be softer than crepe from undilted latex, but there would be little difference in the amount of mastication required to render the rubber sufficiently soft for factory operations. On the whole the crepe from the very dilute latex would require the least mastication.

Imperial Institute,
London,
November, 1928.

REPORT ON THE EFFECT OF ORGANIC ACCELERATORS OF VULCANISATION ON THE VARIABILITY OF RUBBER.

THE vulcanising properties of rubber are usually determined by mixing in sulphur and determining the period of heating at 140-150°C required to produce optimum mechanical properties. This period varies with the sample under examination.

A vulcanised mixture of rubber and sulphur is too soft for most commercial applications, and it is necessary to add other substances, many of which have a considerable effect on the mechanical properties of the vulcanised material. Some also have a marked effect on the time required for vulcanisation. The most important of these latter substances are organic accelerators which are now extensively used to aid vulcanisation and to improve the mechanical properties of the vulcanised product. It has been the practice therefore at the Imperial Institute not only to determine the vulcanising properties of rubber in a rubber-sulphur mixing but also in one containing an organic accelerator and zinc oxide, the latter being necessary for the activation of many organic accelerators.

The comparison between the results of tests in a rubber-sulphur and an organic accelerator mixing is complicated by an important difference as regards the behaviour of the two types of mixing on vulcanisation. Whereas the mechanical properties of a rubber-sulphur mixing change rapidly with the period of vulcanisation, those of an accelerator mixing remain fairly constant for a long period. Consequently in the case of the rubber-sulphur mixing the variation between different samples of rubber can be defined in terms of the time of vulcanisation, but in the case of the accelerator mixing comparisons have to be made as to the ability or inability of samples to attain certain mechanical properties.

The basic mixing used throughout these investigations consisted of rubber, sulphur, zinc-oxide and an organic accelerator. The proportion of each constituent, except that of zinc oxide, is in practice fixed within certain narrow limits depending upon a number of factors. The amount of zinc-oxide however can be varied from the few per cent. necessary to activate the accelerator to an amount in excess of the weight of rubber present. The first experiments at the Imperial Institute (J.S.C.I., 1923, *42*, 98) were made with accelerator mixings containing about 5 per cent. of zinc-oxide on the rubber, and with samples of rubber which had been in stock for several years. Under these conditions remarakable variations in the behaviour

of the different samples was observed. Some of them scarcely vulcanised no matter how long the period of vulcanisation, whilst others had excellent mechanical properties after a very short period of vulcanisation. Further experiments showed however that this variation was confined to accelerator mixings containing about 5 per cent. zinc-oxide. When the amount of zinc-oxide was increased considerable so that equal quantities of zinc-oxide and rubber were present, the differences disappeared.

The variation in the behaviour of samples in the presence of 5 per cent. zinc-oxide was traced to differences in the accessory substances naturally present in rubber. When some of these accessory substances were removed by extraction with acetone, samples which previously vulcanised well in the presence of 5 per cent. zinc-oxide and an organic accelerator no longer vulcanised satisfactorily. When the extracted accessory substances were added back to the rubber during mixing, vulcanisation was again satisfactory.

These results were subsequently confirmed by Sebrell and Vogt (Ind. Eng. Chem., 1924, *16*, 792) who also showed that the important accessory substances were the fatty acids which Whitby (J.S.C.I., 1923, *42*, 336T) had previously shown were present to the extent of over 1 per cent. in most samples of rubber. The experiments of Sebrell and Vogt however were confined to mixings containing about 5 per cent. zinc-oxide. The experiments at the Imperial Institute show that fatty acids are not a source of variation in the presence of large quantities of zinc-oxide. Whitby (J.S.C.I., 1928, *18*, 122T) has recently challenged this conclusion but further experiments, the results of which will shortly be published, confirm its validity.

The remarkable effect of fatty acids in mixings containing 5 per cent. zinc-oxide is considered to be due to a better distribution of the zinc-oxide in the presence of fatty acids. The zinc-oxide is not dissolved in the rubber but is present as separate discrete particles. Most accelerators require a minimum amount of zinc-oxide to reach full activity. The distribution of the zinc-oxide is therefore of considerable importance when only small quantities are present.

The question remains as to the extent of the variability in first grade rubber when vulcanised in accelerator mixings containing 5 per cent. zinc-oxide and an organic accelerator. It has already been pointed out that the samples which displayed so much variation were several years old at the time of the tests and therefore not representative of the crepe and sheet usually employed in the factory. It was subsequently shown by Whitby (Trans I.R.I., 1924, *1*, 12) that the amount of fatty acids in rubber tends to become very small on keeping. It is to be expected therefore that these samples would be variable in the mixing chosen.

Tests were therefore carried out on 39 samples not more than two years old collected from estates, and on others six months old specially prepared by methods known to have a considerable effect on the rate of vulcanisation in a rubber-sulphur mixing. The mixings tried were:—

	(a)	(b)
Rubber	90	90
Sulphur	5	5
Zinc-oxide	5	5
Accelerator	1 hexamethylene tetramine.	1 diphenylguanidine

No variation of importance was observed with the above samples, although both mixings gave unsatisfactory results in the absence of fatty acids. It may be concluded therefore that there are sufficient fatty acids in crepe and sheet (for the first two years after preparation) to prevent marked fluctuations in vulcanising properties in the presence of organic accelerators and 5 per cent. zinc-oxide.

Since it has already been shown that fatty acids do not cause appreciable variability in the presence of larger quantities of zinc-oxide, it might be concluded that accelerators completely eliminate variability in first grade rubber. The results of a large number of experiments by Dinsmore and Zimmerman (Ind. Eng. Chem., **1926**, *18*, 144) however do not confirm this conclusion. A few tests were therefore carried out at the Imperial Institute using one of the mixings employed by the above investigators, and it was found that the accelerator mixings employed by them did not eliminate variability.

The only difference between the accelerator mixings which displayed some variability and those which did not was in the proportion of accelerator and sulphur to the rubber. A study of the effect on variability of the sulphur accelerator ratio had not previously been made, but it is evident from the following results on two estate samples selected at random that it is of considerable importance.

	Addition to 100 parts of rubber.				Sample No. 1215.		Sample No. 1225.	
Mix.	Zinc Oxide	Sulphur.	Diphenyl-guanidine.	Time of vulcanisation at 148° C.	Tensile Strength.	Elongation at load of 104 kgs./sq. m.m.	Tensile Strength.	Elongation at load of 104 kgs./sq. m.m.
	(parts)	(parts)	(parts)	(mins.)	(lbs./sq. in.)	(per cent.)	(lbs./sq. in.)	(per cent.)
1	nil	11·1	nil	100	1150	905	1910	873
2	6·0	2·75	0·4	20	590	—	1250	1035
				30	680	—	1790	931
				40	1010	935	1750	877
3	6·0	5·5	0·4	20	1200	870	1900	861
				30	1550	820	1980	759
				40	1830	754	2140	694
4	5·6	5·6	1·1	25	2880	573	2990	580

In the rubber-sulphur mixing (Mix. 1) samples 1215 required about 10 per cent. longer period of vulcanisation to give the same mechanical properties as sample 1225.

On vulcanising in Dinsmore and Zimmerman's mixing (Mix. 2) the presence of the accelerator and zinc-oxide has increased the difference between the two rubbers. When the amount of sulphur in this mixings is doubled (Mix. 3) there is less difference between the samples, and when the amount of accelerator is also increased (Mix. 4—Imperial Institute routine mix.) the difference between the two samples is negligible.

It is evident therefore that the difference between Dinsmore and Zimmerman's results and those obtained at the Imperial Institute is due to the fact that the former employed much lower proportions of sulphur and accelerator in their mixing.

The proportion of sulphur to accelerator is of considerable importance in manufacturing practice and many manufacturers reduce the amount of sulphur as much as is consistent with satisfactory mechanical properties. A critical ratio can be obtained for an accelerator (Schidrowitz and Burnand J.S.C.I., 1921, *40*, 268T) below which it is not good practice to reduce the amount of sulphur present. It seems likely from the above experiments that this critical ratio varies with the rubber. The question has not yet been studied extensively but there is some evidence that the serum substances are the cause of this variability.

The experiments with the mixings employed at the Imperial Institute indicate that all variability in first grade rubber can be avoided by using suitable proportions of sulphur and accelerator. There are other and more important considerations however which affect a manufacturer's choice of a mixing for any purpose, and it is understood from several independent enquiries that the mixings employed by Dinsmore and Zimmerman may be regarded as typical of manufacturing practice. With these mixings there is a certain amount of variability, but there is no evidence that wide variations are liable to occur such as are sometimes experienced in a rubber-sulphur mixing.

Imperial Institute,
London, S.W., 7.
February, 1929.

SELECTED ARTICLES.

PRELIMINARY NOTE ON THE OCCURRENCE OF RHIZOCTONIA BATATICOLA IN JAVA AND SUMATRA; DISEASES OF TEA IN NYASALAND.

[The following two extracts are of interest to those who have followed recent developments in the question of the causation of root disease by fungi. The first extract discusses the occurrence of *Rhizoctonia bataticola* in the Dutch East Indies, a question to which attention was directed by the work done in Ceylon in 1926 and 1927; it supports to a certain extent the contention that the sole association of *Rhizoctonia bataticola* with cases of root disease means that the fungus must be regarded as a parasite. The fungus is now known to occur in apparently healthy older roots of tea and rubber in Ceylon as well as in a mycorrhizal condition in the smallest roots; and it is probable that the mycorrhizal fungus of tea and *Cinchona* in Java is also *Rhizoctonia bataticola*. Future investigation may therefore take, as Dr. Steinmann remarks and as has been realised in Ceylon, the form of a search for an explanation of the passing of the fungus from a mycorrizal form confined to feeding rootlets to a parasitic form which advances into and kills the roots, provided it is shown, in the first place, that *Rhizoctonia bataticola* may and can remain in the mycorrhizal condition without harm to the plant.

Rhizoctonia bataticola has also been found to attack tea in Nyasaland. It is referred to under its correct but less known name *Macrophomina Phaseoli*. Dr. Butler also gives notes of interest on *Armillaria, Ustulina* and *Diplodia* which should be read in conjunction with pages 224-227 of *The Tropical Agriculturist* of October 1928. Dr. Butler's remarks concerning the relationship between disease and soil erosion are worthy of study.—*Ed., T. A.*]

PRELIMINARY NOTE ON THE OCCURRENCE OF RHIZOCTONIA BATATICOLA IN JAVA AND SUMATRA.*

THE presence of *Rhizoctonia bataticola* on the roots of different plants has been ascertained for the first time by the writer towards the end of 1927 in Java and in May 1928 in Sumatra. In Java, the fungus has been found on roots of tea, *Albizzia* and rubber; in Sumatra on tea and *Albizzia falcata*. On tea, the majority were cases of attacks by *Rhizoctonia bataticola* alone; in two cases, *Rhizoctonia* was accompanied by *Diplodia* and in one case on rubber by the white root disease *Rigidoporus microporus*. Material from tea-roots was sent to DR. SMALL in Ceylon who confirmed our supposition that we were dealing with the same fungus as occurs in Ceylon.

* English summary of an article by Dr. A. Steinmann in *Archief voor de Theecultuur in Nederlandsch-Indie*. No. 1-2, June, 1928.

Rhizoctonia bataticola is generally to be found in the tissues of the finer roots, both in wood and bark and only in exceptional cases also in the thicker and greater parts of roots. On their exterior the affected roots show no obvious symptoms of disease. Internally they show sometimes a brownish and greyish discoloration. The wood however is always—as already pointed out by SMALL—hard, dry and brittle. The greyish discoloration resembles closely that caused by the *Diplodia* root disease and if the two fungi occur together it is not easy to distinguish them from each other.

On maize meal agar cultures the fungus forms first colourless hyphae which quickly turn brown. Clamp connections occur sometimes. The cells are generally irregularly swollen and show at the septa distinct constrictions. The agar media turn after a few days dark in colour. The young cells are filled with oil globules. In culture as well as in tea-roots sometimes rounded swollen cells occur which soon turn dark-brown in colour and are considered as chlamydospores. The most characteristic feature of *Rhizoctonia bataticola* is however the presence of the small black sclerotia in the cortical tissues or on the wood and the occurrence of the so-called sclerotial plates of various shapes in the tissues of the root. In culture sclerotial formation begins generally at the edge of the nutrient medium where the sclerotia appear as small black points. The sclerotia in the tissues appear under microscopical examination as black spots assuming the form of the cells. After bleaching and treating with hydrate of chlorine the pseudo-parenchymatous mass of cells is distinctly visible. The cell-walls are dark brown and comparatively thick. The sclerotial plates vary considerably in size, owing to the form and size of the cell cavities they occupy. First, in the mass, the hyphae are readily distinguishable from each other; later on, the structure of the component hyphae is hardly distinguished owing to the dense growth of the tangled mass of cells which becomes pseudo-parenchymatous. At the same time the hyphae disappear from the tissues.

With reference to the spreading of *Rhizoctonia bataticola* in Java and Sumatra, the fungus has been found at various elevations and in different types of soils, on estates with very variable climatic conditions, on comparatively low-lying tea estates and at high elevations. Special attention shall be drawn upon the possibility of a relation between the occurrence of the fungus and the chemical and physical condition of soils, but until now one has been unable to find in the environment a constant condition which leads to susceptibility to *Rhizoctonia*. With reference to the acidity (pH and Daikoehara) the comparatively few samples until now examined (9) show no definite connection between the degree of acidity and the occurrence of the fungus.

Regarding the question which arose in Ceylon whether *Rhizoctonia bataticola* is to be regarded as a parasite or as a saprophyte, the fact that we have found *Rhizoctonia bataticola* on diseased tea *alone* may prove that the fungus is able to kill woody plants in Java and Sumatra without assistance of any other fungus and can therefore assume the behaviour of a true parasite. On the other hand the recent finding of *Rhizoctonia* in mycorrhizal form by Park in healthy tea roots in Ceylon may be explained in this way, that it is a common mycorrhizal fungus which under certain conditions can become parasitic. The writer has also found in Java endotrophic mycorrhiza in healthy roots of tea and of *Cinchona;* therefore the question is for the Netherlands Indies too of some interest. Further investigations shall be needed to state the conditions which enable *Rhizoctonia bataticola* to act as a true parasite.

DISEASES OF TEA IN NYASALAND.*

The main tea district of Nyasaland extends from south-east to south-west along the foot of Mlanje mountain, for a distance of about twenty miles, at an elevation averaging 2,500 ft. above sea level. It rises from the Shiré Highlands, a wide and extensive plateau, on the south-eastern corner of which Mlanje is situated. The rainfall varies from about 70 to 90 inches, diminishing as the western extremity of the district is approached and also as the ground falls away from the mountain towards the plain: in general it is greater the nearer the mountain face is approached. In the western half of its extent the main mass of the mountain rises abruptly from a moderate to steep slope at its base. Towards the south-east, however, the ground is more broken by foot-hills and valleys. In both areas tea can be grown up to the steeper slopes which extend along the base of the cliffs that form the greater part of the 6,000 to 9,900 ft. to which the mass rises above sea level. These cliffs form almost vertical scarps, 4,000 to 5,000 ft. in height, along the southern and western faces of the mountain. Away from the mountain tea is found only to a distance of a few miles towards the plain. The rainfall is the limiting factor to extension, both in the length and breadth of the Mlanje tea district, except to the east where the Portuguese frontier intervenes.

Several permanent rivers and streams traverse this area from the mountain towards the plain, and in the rainy season the cliffs are seamed with dozens of waterfalls owing to the very high precipitation on the upper levels of the mountain. The Great and Little Ruo Falls, the former some 800 ft. in height, carry permanent streams that unite towards the Portuguese border to form the Ruo river, one of the main rivers of southern Nyasaland.

Practically the whole of this area was within recent times clothed with virgin forest, mostly of medium or small trees but reaching a good size along the streams. In a few cases the tea gardens have been cleared from grassy slopes with scattered trees, but most of those now in bearing were till recently fairly dense forest, and this is, no doubt, the explanation of the particular types of disease most prevalent in the tea. Some of the existing gardens were originally cleared for coffee planting, but even in these cases the conditions often remained almost like those of a forest, owing to the large trees employed as shade and the growth of the coffee itself.

The soils are lateritic, varying in colour from red to grey, chocolate, or deep brown, and are weathered from the orthoclase-hornblende-syenite of Mlanje and the older metamorphic rocks, including a variety of crystalline schists and gneisses, of the Shiré Highlands. They are, in general, adequately to richly provided with the essential plant foods, the phosphorus, however, being largely in an unavailable condition. The percentage of iron and aluminium is high and the soil reaction is generally acid. The darker soils are rich in organic matter. On the slopes and ridges the soils are generally very deep and the texture is open, permitting free drainage and aeration. In the hollows ("dambos") which are a characteristic feature of the Nyasaland highlands, the clay sub-soil may come near the surface and the soil is stiffer, requiring deep drainage. In these hollows root disease is, so far as I could observe, entirely absent from the tea, but I was informed that they were ordinarily devoid of trees and this, rather than soil conditions, may be the reason for their immunity from root disease.

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* By Dr. E. J. Butler, C.I.E., F.R.S., Director of the Imperial Bureau of Mycology. Issued by the Department of Agriculture, Nyasaland, July 1928.

Round Mlanje the tea flushes in the rainy season from December to April, but plucking becomes impossible when the flush is checked as the cold weather sets in. This immediately follows the rains and precedes the hot season in October to December. That crops exceeding 500 lb. to the acre can be obtained in a four months' season, during which there is also a constant battle with the weeds and grass which grow so fast that they can scarcely be held in check, is a sufficient tribute to the fertility of these soils and the forcing effect of the rainy season. Much of the rain falls in short sharp showers, succeeded by periods of bright hot sunshine, and these conditions induce an intensity in the development of weeds and in the flushing of the tea with which none but exceedingly fertile soils could cope. This fertility is natural, since manuring is by no means general; when the land is first cleared it appears to be high in both the top and deeper layers of the soil, but after clearing there are indications that the top soil loses fertility through the action of wash and possibly of other factors as well. In analyses of severely washed, unfertilized Mlanje soils that I have seen, where no attempt was made to separate the surface from the sub-soil, the results indicate that the essentials for good tea soils are more fully provided than is common in Ceylon.

In the rest of the Shiré Highlands the rainfall is generally insufficient for tea. The area suitable for tobacco is large but the only other district in which tea is being planted is Cholo, where with a rainfall of only about 60 inches and a colder climate, crops of 400 lb. to the acre are likely to be difficult to obtain. In Mlanje, however, less than half the available land suitable for tea is at present in bearing, and extensions now contemplated should more than double the output. The yield per acre is also being increased in some gardens by fertilising and improved soil and bush management, while in quality, at present distinctly low, there is also evidence of improvement with the growing of better "jats" (varieties) of bush and more experience in manufacture. Both yield and quality are at present low on the average and one, or preferably both, must be improved if the district is to prosper in the face of rising labour charges. The labour is mainly migratory, and is short from December to February but generally sufficient for the rest of the year. The shortage in the early part of the rains is the chief reason for the frequent failure to keep the weeds down during the period, in which the bushes may become almost hidden from sight in the long grass and other vegetation.

Considering the physical and chemical properties of the soil, the root development of the tea is somewhat disappointing. This is particularly noticeable in young bushes, one or two years after planting out. In such bushes it is common to find no lateral root development in the first eight or ten inches of soil. Small laterals form but fail to provide a root system. Taproot development, however, is vigorous and lateral systems of considerable size early appear in the deeper layers. Subsequently, a surface lateral system arises below the collar of the bush, no doubt as a result of the vigour imparted to the plant by the deeper systems. The mature bush has frequently a substantial growth of stout laterals a few inches below the surface of the soil, the taproot continuing to show strong laterals as it is followed down, but in many cases the young bushes have no hold in the surface soil and if the taproot is broken at a depth of eight or ten inches the bush comes away with a slight pull. Even in mature bushes there is often a lack of surface feeding roots, while a tendency for the stout surface laterals to turn down towards the deeper layers has also been noticed.

In endeavouring to account for this type of root development, which must reflect on the vigour and health of the bushes, attention was early attracted to the prevalence of soil erosion and surface wash. It was quite

evident that many of the slopes had suffered severely in the past from the loss of the surface soil by rain washing. A rainfall of two inches in an hour is said to be not infrequent in the early part of the rainy season, and a fall of nearly nine inches in 24 hours occurred during my visit. Under such conditions the loss of surface soil must be very severe when the protection of the forest is removed. The loss will vary with the steepness of the slope (rate of flow of the water) and the nature of the soil. The organic matter and fine particles, of most importance to fertility, are the most readily affected by wash and with their loss there is a reduction in the water-holding capacity of the soil. The first heavy rains after the hot season are likely to be the most destructive; later on the growth of weeds and drainage by the establishment of percolation to the lower layers of the soil may diminish the damage. During the hot dry weather, however, the weeds die down, and the less deep cultivation the soil gets the greater the run-off on the first rains and the resulting loss of fertility in the upper layers. The Nyasaland Agricultural Department called attention to the evils of soil erosion in the strongest terms in Bulletin No. 1 of 1924, in which Captain A. J. Hornby, the Agricultural Chemist to the Department, stated that "tree growth has been destroyed for native gardens down to the banks of streams, and with no precautions we may say that the run-off has risen from 33 per cent. in the forested areas to 69 per cent. of the annual rainfall on such lands. The agricultural capital has been allowed to run to waste and can never be replaced by any system of manuring." These warnings, together with the advent of planters with recent Indian and Ceylon experience, led to a serious effort being made in some tea gardens to combat erosion. In a great many places, however, the damage had already progressed very far, and in some new areas are still being cleared without any provision for checking wash. In these last cases the top soil constituents of value for the feeding purposes of the tea plant are being removed faster than they are formed and a quite obvious diminution in fertility is taking place. That this, in itself, is capable of influencing the progress of root diseases is indicated by the fact that in certain gardens where no effort has been made to combat disease directly but where wash has not, for one reason or another, been severe, and manuring has beeen practised to some extent, the patches of root rot, though numerous, are mostly of small extent and slow spread. In these gardens the susceptibility to prevailing root diseases is clearly less than where wash has been severe and soil fertility has been allowed to decline.

Field observations indicate that the types of root disease most commonly found in the Mlanje tea are those which are most easily able to affect bushes with a relatively weak root development. Other root fungi of types which are indifferent to the vigour of their victims (well-known examples of which in other crops are the *Fusarium* wilts) do not appear to occur. The poor development of the bushes on severely washed slopes, as evinced by the absence of spreading growth, the yellow colour of the leaves, and weakness of flushing is accompanied in most cases by outbreaks of disease and is, in my opinion, one of the two main factors which have assisted in causing the unusual prevalence of root diseases in this area. Whether there are other minor factors, working in the same direction as that just discussed in weakening root development, is uncertain. It is possible that the apparent infertility of the upper soil layers may be in part due to the heavy falls of rain forcing the soluble plant foods down to the lower levels. It is also possible that the dry season is sufficiently prolonged to cause drought conditions in these layers, so that the early formed laterals cannot obtain sufficient moisture for their development. Weeds may also play a part by enfeebling the growth of the green parts of the bush and thus diminishing

the plant food required for forming a strong root system. Observations carried on for a more prolonged period would be necessary to determine these points.

The second main factor predisposing to root disease in the Mlanje tea is the wide-spread failure to "stump" the ground when it was first cleared from forest. Only in a few cases were the stumps and main roots of the forest trees removed: in most gardens they were left to decay in the soil, with the same result that has been experienced in all tropical and sub-tropical countries when this precaution has been neglected. As the stumps decay, patches of dying tea are noticed around them, and these may continue to expand for a considerable period unless arrested. I have not seen an adequate explanation of this phenomenon, though the immediate cause of the death of the bushes—the action of certain parasitic fungi which attack the root—is well known. How it is that these fungi require the presence of decaying wood, usually in large masses, to start them into activity is obscure. As in other countries, so in Nyasaland, it has been noticed that certain trees are more apt to start root disease than others. The planters generally were agreed that the two worst trees in this respect were the "Mwanga" (*Afrormosia angolensis*) and the "Muula" (*Parinarium mobola*), the former a very hard wood and the latter moderately soft. As also in India and Ceylon, there is no evidence that the trees most implicated in this trouble are related to one another either botanically or in their physical characters. *Grevillea robusta,* which is found in some numbers as a shade tree in the tea, has not yet reached an age when its well-known tendency to start root diseases would show up: observations in other countries show that the tree is harmless so long as it is growing, and only becomes a menace after it is cut down and the stump left to rot in the ground. *Albizzia moluccana*, another known offender, is occasionally used as shade and will, no doubt, prove as troublesome as it has been in Ceylon. The indigenous *A. fastigiata* ("Chikwani") is suspected but has not been proved to cause trouble. Others, such as a local *Ficus,* were mentioned to me as dangerous, while the "Mbawa" or African Mahogany (*Khaya senegalensis* var. *nyasica*) belongs to a genus that is known to be susceptible to one of the root rots (*Armillaria mellea*) prevalent in Nyasaland, but whether it can initiate an attack is uncertain. It is obvious that definite information on these points could only be obtained during a longer period of observation than was available to me.

Enquiries led to the conclusion that the root disease patches begin to appear usually about five to seven years after the forest is cleared, and they may persist, if unchecked, for many years. Mwanga stumps were found still fairly sound after fifteen years, and there is no reason to doubt that such stumps could initiate delayed outbreaks, just as in India and Ceylon attacks are known to have started from stumps fourteen years old.

Of the four fungi hitherto identified as causing root diseases of tea in Nyasaland, two, namely, *Armillaria mellea* and *Ustulina zonata,* are forest fungi. The former is known to be able to attack potatoes, but the disease thus caused is exceedingly rare and, in general, it may be said that annual plants growing in arable soils are free from both species. What may be called forest conditions—shade, undisturbed soil, plentiful supplies of organic matter, high soil moisture, and the like—further their development. So far as I am aware they are generally found in other countries only to a moderate depth in the soil and their presence below two feet appears to be rare. In the loose, well-aerated Mlanje soils, however, they go deeper, at least to two-and-a-half feet. Moisture is essential to their growth and, leaving aside the hollows known as "dambos" already mentioned, they appear to be more prevalent the moister the soil. The low evaporation

from, and high moisture capacity of forest soils are, therefore, particularly favourable to these two fungi. At first sight it might appear that the soil conditions on the washed slopes in which root diseases are most prevalent are not such as would favour these fungi. They undoubtedly persist, however, on the rotting timber in these soils, the absence of drainage and the poor cultivation help their development, and the weak root system in the top soil renders the bushes particularly susceptible to their attack.

The other two, *Botryodiplodia Theobromae* and *Macrophomina Phaseoli*, are found in arable and grass as well as forest soils and are known to attack annual plants. The conditions favourable to their development are clearly not the same as with the first two, and there is little evidence that they start from rotting stumps.

Besides the diseases caused by these four fungi another, and in some respects the most serious, of the tea diseases encountered in Mlanje has many of the characters of a root disease, though no parasite has been found in the roots of affected bushes. Its occurrence will be more fully discussed below.

Throughout the whole of Mlanje tea district these five diseases occur probably in every garden. Stem and leaf diseases also are found but, except for the stem canker associated with the *Macrophoma theae*, are of little importance. In particular the two serious diseases, red rust, caused by *Cephaleuros parasiticus*, and thread blight caused by several species chiefly of the genera *Corticium* and *Marasmius*, are known. The harmless leaf form of red rust (probably due to the allied *C. mycoidea*) is not uncommon, but a careful search failed to disclose any but a few small superficial patches on the stem, usually just below the insertion of the leaves. Of the leaf diseases, the grey and brown blights (*Pestalozzia theae* and *Glomerella cingulata*) occur, as they do wherever tea is grown, but the damage done by them was negligible during the period of my visit, though I was informed that they had been severe in places in 1926, possibly as a concomitant of the rather severe infestation by mosquito blight (*Helopeltis bergrothi*) in that year. Even in the oldest tea seen (there are a few areas with bushes over 30 years old) the above-ground parts of the plant were remarkably clean and free from blights, possibly as a result of the relatively long dry period in the climate of the district. Of the serious root diseases of tea known in other countries, those due to *Rosellinia* spp., *Fomes lamaoensis*, and *Poria hypolateritia* were not encountered.

In the tea seedlings still in the seed-beds *Macrophomina Phaseoli* was associated with a rot at about the level of the seed, and heat canker was found in a few cases. In young tea (one to two years after planting out) *Botryodiplodia Theobromae* and *Ustulina zonata* caused more deaths than either *Armillaria mellea* or *Macrophomina Phaseoli*. The disease of unknown causation may also have been responsible for some of the losses in young tea, but its incidence at this stage was not easy to determine. *Macrophoma theae* was reported to have been destructive in seed-beds and young tea in 1926, but owing to the vigorous control measures adopted was only prevalent during my visit in a few areas of planted-out tea that had not yet been pruned. Spreading patches of root disease were not observed in young tea. In the mature gardens *Armillaria mellea* and the obscure disease were far more frequent than the others. *Macrophomina Phaseoli* was infrequent on full grown bushes and was only once found on the roots of a dead bush unaccompanied by any other pathogenic fungus, though somewhat more common on single dead roots, in one case accompanied by death of a few branches above.

A more detailed account of these various diseases, the only ones of importance observed, follows.

ROOT AND COLLAR CRACK CAUSED BY ARMILLARIA MELLEA.

The tea disease caused by *Armillaria mellea* has previously only been reported from Java, where it is found mostly at altitudes of 4,000 ft. or over, *Cinchona* also being attacked, and from Uganda, where it is said to be the commonest cause of root disease in a considerable number of woody plants, amongst which tea is mentioned. The fungus itself, a well-known species in temperate zones, is not common in the eastern tropics; it has not been seen in Ceylon, while in India it has only been recorded at rather high altitudes (over 7,000 ft.) in the Himalayan pine forests. In Africa, however, it is more frequent; in the Gold Coast it is the cause of a serious disease of cacao (*Theobroma cacao*) to which the name "collar crack" has been given, and has also been found attacking the African mahogany (*Khaya spp.*), mango (*Mangifera indica*), avocado pear, *Cola acuminata, Chlorophora excelsa, Funtumia africana,* coconut, the oil palm (*Elaeis guineensis*), and other trees and herbaceous plants, while in North Africa it causes a root disease of fig trees. In Nyasaland Mr. J. B. Clements, Conservator of Forests, has reported it on the Mlanje cedar (*Widdringtonia whytei*), the successful planting of which on Zomba Mountain has been seriously interfered with on account of its ravages, and I saw mangoes, *Cedrela toona,* and *Poinciana regia* dying from what appeared to be the same disease, while the brown collar rot of coffee observed in the Ncheu District is possibly due to this fungus.

On tea it causes a wet rot affecting tap root and main laterals, sometimes also extending into the stem well above soil level. The rot is so wet that water can be wrung out of the affected roots which in late stages of the disease become softened and pulpy. This wet rot is also frequently found in cacao affected with collar-crack and has been ascribed to the action of secondary bacterial invasion. The chief symptom on the affected parts is the presence of conspicuous, raised black lines or narrow bands running longitudinally on their surface and usually representing the external growth of radial sheets of mycelium (xylostroma) which ultimately disrupt the wood in the direction of the medullary rays and lead to radial cracks separating the affected root or stem into elongated, wedge-shaped strips. In the early stages the woody tissues remain firm, but it soon becomes possible to tear the root longitudinally into two or more strips, the inner faces of which are lined by white or dingy mycelial sheets. At a later stage the whole of the wood softens and rots. The cortex is early penetrated by sheets and strands of white mycelium, running chiefly parallel to the surface of the bark and producing a mottled appearance, due to alternations of white mycelium and brown bark, when the latter is shaved away tangentially. On careful dissection the sheets are found to form a more or less continuous layer, which, when growth is active, extends either through the middle of the bark or just external to the cambium for a considerable distance, the growing margins being spread out fanwise. These symptoms are very similar to those described on cacao in the Gold Coast and they exactly resemble those shown in the photographs of the split-canker of tea in Java caused by *A. mellea.* Rhizomorphs are occasionally found on the surface of the affected roots as black, rounded or flattened strands, closely resembling black roots, a couple of millimeters or more in diameter. They are rare under African conditions and were only found on one tea bush in Nyasaland. This bush, which was nearly dead from a typical attack, also bore clusters of sporophores, medium-sized toad-stools, in its

centre and other similar clusters were found around the base of a dead *Poinciana regia* tree bordering the tea, in a line in which several deaths had occurred from root disease. Sporophores are evidently formed much less often in tropical Africa than in Europe and they are generally smaller and more deeply coloured and the fungus forms rhizomorphs less regularly than in the temperate forms of *Armillaria mellea* so familiar in woods in England. In Java the form which causes the white root rot of *Cinchona* has been grown in pure cultures in which it produced toad-stools in clusters of two or more, yellowish-brown to brown, the stalks 5 to 6 cm. high by 5 to 6 mm. broad and caps 5 to 6 cm. across. No ring is present in the mature specimens of this form, but one can be seen when they are young. The spores are hyaline, ovoid-elliptical or elliptical and slightly pointed, measuring 7 to 9 by 5 to 6 microns, and borne on whitish gills which touch the stem and are somewhat decurrent. Rhizomorphs are not abundant but form readily in culture. Still smaller forms occur in the Java Mountains and in the Cameroons and have been recorded as *A. mellea* var. *javanica* and var. *camerunensis,* respectively; the first is described as lurid brown, darker at the top, 2 to 3 cm. in diameter, with a hollow stalk up to 5 cm. high and 2 to 3 mm. thick, a white ring, adnate gills, and hyaline, subglobose spores, 6 to 8 microns in diameter, while the second was only ½ to 1 cm. across. The Nyasaland specimens were too old for accurate description but they would pass for old *A. mellea,* and the presence of rhizomorphs and general characters of the disease leave no doubt as to its causation by this fungus.

The most severe attack of *Armillaria mellea* observed was in a garden planted in 1915 on land cleared from forest containing a considerable number of trees of *Parinarium mobola* and *Afrormosia angolensis*. Some ten acres were affected and 75 per cent. of the original bushes had been killed. The field sloped down to a deeply-drained valley at right angles to the forest which bounded it on one side, and was separated by a road on the side opposite the latter from another garden of the same date. A great part of the ridge and slope had bare patches and young supplies, but the bottom of the slope was without a single case of disease and the latter was less severe on the side furthest from the forest, though patches reached the road in several places. That the road had checked extension considerably but not entirely prevented it was evident from the fewness and small size of the patches in the part of the second garden adjoining it. Out of some 20 bushes examined, only three were without symptoms of *Armillaria* attack in the top foot or so of the root system and these possibly were affected lower down. The bushes died gradually and generally from one side, this unilateral type of attack being characteristic of most of those caused by *Armillaria* that were seen. The garden had not been stumped after clearing from the forest, there was no shade, weeds were few, and wash had been unchecked and was doubtless considerable.

A few miles away, in another estate, several gardens of heavily shaded old tea were seen in which there were numerous patches of root disease of the same type, but these patches were small, isolated from one another, and evidently spreading slowly. The soil had been fertilised with cattle manure and a growth of low weeds encouraged with a view to checking wash. In this estate, where the tea bounded the still-standing forest, its edges were scalloped with numerous semi-circular patches of larger size than those in other parts, the appearance strongly suggesting that the attack was extending into the tea from the living forest. I was informed by Mr. Clements that this phenomenon was very apparent in his Mlanje cedar plantation and that he had checked it by trenching. The relatively low percentage of loss in these last mentioned gardens may be attributed to the

vigour of the bushes resulting from fertilising and the prevention of wash, as stumping had not been done. Where extension was going on, the attack on the bushes was nearly always unilateral, half the bush often being dead while the rest was more or less normal.

Similar small, sharply-defined patches were seen in another estate in gardens cleared from very heavy forest in 1911-12 and stumped after clearing. Some of the old *Afrormosia* stumps were still undecayed. The attack was generally unilateral and every case examined had the typical root cracking. It is evident that neither stumping nor fertilizing will prevent the attack of *Armillaria mellea,* but the small patches in the two last mentioned estates should be easy to control.

Apart from these spreading patches (various intermediate types of which between the small, sharply-defined patches and the larger, irregular ones often intercommunicating, were seen), a number of isolated deaths from the same type of root rot were met with. The attacks killed the bush very rapidly, causing it to wither up completely with its leaves still attached. These single withered bushes with brown or even still green dead leaves are very conspicuous. In one place three of them were found near together and a patch was probably starting, but wherever good sized patches were established, the deaths at the margin of the patch were gradual and preceded by the shedding of the leaves. Even in these gradual deaths it is rare to find new shoots arising from below the diseased branches, though new ones may continue to appear from the sound parts of the bush. In one or two cases, however, a few healthy surface lateral roots from which healthy roots arose were found in bushes, of which the rest of the root system and above-ground parts were dead. In the only instance in which this disease was found in young tea, the bush died in its second year after planting out and its taproot was marked by the characteristic black lines on the surface and mycelial sheets in the bark.

Microscopic examination shows that the mycelium penetrates all the tissues of the affected roots and collar, the hyphae passing from cell to cell either through the pits in the cell walls, or by boring through the latter. Three types of mycelium are found, a colourless feeding mycelium of slender, branching, hyaline hyphae; a brown stromatic mycelium confined to narrow layers that appear as black lines when the wood is cut; and a white or yellowish aggregated mycelium forming the sheets in the cortex and in the cracks in the wood, sometimes coming to the surface, where the free edge turns black and produces the thick black bands on the surface of the affected parts. These last are a transitional form to the true rhizomorphs, which are free, thick, leathery, black strands, sometimes flattened and resembling bootlaces, sometimes rounded and like roots spreading through the soil.

The exact manner of infection was not determined, beyond that it was associated in the early stages with the presence of rotting stumps or buried timber in the soil. In temperate countries infection occurs from rhizomorphs which spread through the upper layers of the soil and infect healthy roots with which they come in contact. In Uganda also spread by rhizomorphs is stated to have been observed tea bushes having become infected by rhizomorphs which had passed over from a diseased ceara rubber tree (*Manihot glaziovii*). In the Gold Coast spread occurs along the roots, and infection is due to direct root contact. In Nyasaland it is probable that, even though rhizomorphs are rare, spread occurs through the soil, the frequently even centrifugal spread being difficult to explain in any other manner, since the larger tea roots are not often in contact.

Infected roots always show the white sheets of mycelium in and under the bark, and the formation of these appears to take place at an early stage. Underneath them the wood is permeated by hyphae. Under condi-

tions that are not understood these hyphae tend in certain places to form swollen bladder-like cells completely filling the cell cavities of the host. This formation starts in the medullary rays and it is possible to find stages in which it is confined to them. More usually, however, it occurs in a continuous layer, reaching from near the surface of the wood to a variable depth towards the centre, and involving all the cell elements, tracheids, fibres, and wood parenchyma. When the band, as is frequently the case, extends along the natural grain of the wood of the root, splitting occurs owing to the destruction of the cell walls, of which frequently nothing but the spiral or scalariform thickenings are left. The cracks thus formed are usually but by no means invariably radial, tangential cracks being not uncommon. When the band crosses the natural grain it does not lead to splitting. The stages of the development of this bladder-like mycelium are accurately described by Hartig, but it was not accompanied, in the trees observed by him, by cracking of the wood. The latter phenomenon, indeed, appears to be rare in the forms of attack seen in temperate countries.

The bladder-like mycelium is at first colourless and thin walled, but soon turns light brown and the walls thicken. In advanced stages the band, seen in section as a narrow black line, consists of a dense mass of angular, often rather small, cells, of a deep brown colour, completely occluding the cavities of the invaded host cells. When cracking occurs or the cell destruction gives room for further development, an extension of fungal growth takes place in the form of masses of elongated, closely appressed cells, which develop into sheets filling the space. Even before any crack is visible these sheets may be found on microscopical examination starting from the stromatic layers of bladder cells. The sheets are much less highly coloured than the bladder-mycelium and may even be almost white, and they are fringed by a silky outgrowth of very fine hyphae, the lumen of which is almost or quite occluded. At the surface they turn black and thicken up into almost cylindrical masses of protrude from the crack in the form of a black frill. A similar formation can occur in the cortex, typical black bands being sometimes found arising from the white sheets in the bark when the wood below shows no signs of splitting or even of the black lines that precede the formation of a crack.

In the accounts of black-line formation by this fungus that have previously been given, it is stated that the lines move gradually forward as the rot progresses into the tissues, marking the limit between two different stages of the decay of the latter. As new host cells are filled with the bladder-mycelium in the direction in which the rot is advancing, those behind become emptied by the bleaching and dissolution of the fungus cells. While it is true that the line divides the wood into areas that differ in appearance and in the extent of the decay that has been caused, no evidence was seen that its position progressively shifts forward. It appears to be laid down in the position that it continues to occupy definitely and the subsequent changes that occur in the same position often lead to the formation of a crack. The whole process is much more like the development of some defensive reaction on the part of the host or the parasite.

The measures to be adopted for the control of this disease will be given after that next to be described, as they are generally similar in the two cases.

STUMP ROT CAUSED BY USTULINA ZONATA.

Of the several forms of stump rot, that is to say diseases arising from rotting stumps in the soil, that caused by *Ustulina zonata* is the commonest on tea in Ceylon and probably also in India. The parasite is widespread

throughout the tropics, attacking a number of woody plants, the most important of which is Para rubber (*Hevea brasiliensis*). It frequently infects coffee, tea, rubber, and the like on old forest land in Kenya, where even temperate fruit trees, such as the peach and pear, have been killed by it. It is also known to occur in Uganda and the Gold Coast but does not seem to have caused serious losses in either case. In Java, where it is known as the root-collar disease, a few serious outbreaks have been recorded, but as a general rule *Ustulina zonata* is not regarded as a serious trouble in tea in that country. The fullest studies of its parasitic action have been made on rubber, and in this host conclusive proof of its parasitism has been obtained by inoculation experiments.

No certain cases of root disease of mature tea associated with the presence of this fungus alone were observed in Mlanje. Only in diseased young bushes was *Ustulina zonata* found alone, though it must be presumed from experience elsewhere that it is capable by itself of killing the mature bushes. I also failed to find its fructifications on tea, though these are usually fairly frequent where the disease due to it is present, and the diagnosis is, therefore, open to some doubt. Ripe fructifications were, however, obtained from just above-ground level on the trunk of a *Poinciana regia* tree bordering the tea and suffering from the root disease typical of this fungus, which had resulted in a weakening of the root system and led to the tree being blown down by the wind. They were also collected in a similar situation on an unknown forest tree that had been removed from the tea in another estate.

In a typical attack of *Ustulina zonata* the tea dies out in spreading patches, which in Ceylon usually start from the stumps of *Grevillea robusta* or *Albizzia moluccana*. The parasite spreads chiefly below ground, though cases have been reported of aerial infection through its spores reaching wounded surfaces, such as pruning cuts, in India and Ceylon, and similar wound infections are not uncommon on rubber in Malaya. In the soil, spread is only possible when an infected root touches or lies very near a healthy one, the mycelium, unlike that of *Armillaria mellea,* extending only along the roots and through the soil. In some cases in Ceylon a line of dead bushes has been found to follow the course of a main lateral root of *Grevillea* or *Albizzia*. The bushes may be killed rather gradually, losing their leaves little by little, or quite suddenly with most of the leaves attached and either brown or still greenish. In spreading patches the attack is often unilateral, part of the bush dying while the rest appears almost normal. As in the case of bushes attacked by *Armillaria* it is rare to find suckers or new shoots arising from below the killed branches

The affected roots bear no external mycelium except black lumps or crusts, in this resembling *Armillaria* where, however, the external crusts are arranged in narrow longitudinal bands. In the bark, too, the symptoms of the two diseases are somewhat similar, except that the sheets are smaller, more fan-shaped, and creamy-white in *Ustulina* instead of being in large uniform layers and often pure white, as in *Armillaria*. There is no tendency to cracking of the wood, but the latter is marked with sharp, angular or wavy black lines, very similar to those caused by *A. mellea* both in appearance and in the manner of their formation.

The absence of longitudinal black bands or frills on the surface of the bark and of radial cracking of the affected wood enables this disease to be readily distinguished from that due to *Armillaria*. It was never found by itself in Nyasaland causing spreading patches of disease, and in every case seen where single mature bushes died without shedding their leaves, *A. mellea* was present and seemed to be the cause of death. It is, therefore,

uncertain whether *U. zonata* is a primary cause of disease of mature tea in Nyasaland, though the knowledge of its presence in young tea and in the forest makes this highly probable.

In young one to two-years-old tea *Ustulina zonata* was sporadic and usually associated with *Botryodiplodia Theobromae,* an association which was not found in older bushes. Occasionally it seemed to occur alone, the attack then being near the soil level. These isolated attacks in young tea near the surface of the soil can scarcely have been due to spread from previously diseased roots but had much more the appearance of wound infection from spores, probably associated with injuries during cultivation.

The fungus at first penetrates the bark and reaches the junction of the bark and wood where it spreads out to form delicate creamy-white fans. It then penetrates through the medullary rays into the wood, where the same two types of mycelium are found as in *Armillaria.* The bladder-cells forming the black lines do not, however, cause any splitting of the wood and do not grow out to form sheets or black xylostroma. The only part that reaches the surface of the root is ordinarily the fructifications, which arise on the collar and larger diseased roots when these are above soil level. The mycelium in these situations spreads out on the surface in small yellowish-white plates, lying close to the bark but only attacked at one point. Frequently several plates unite by their margins to form fairly extensive, corrugated sheets, several inches across. The single fructification is zoned, and when mature is finely punctate with black dots which mark the mouths of the spore receptacles. Before this stage, however, when the surface of the plate is still whitish and soft, very small spores (conidia) develop in a continuous layer covering the plate, and as these have been shown to be able to give rise to cultures of the fungus they must play a part in disseminating the disease. The perfect stage arises later, when the crust is dark brown or blackish-purple and brittle, in the form of a layer of flask-shaped spore receptacles (perithecia) buried just below the surface of the crust, only their mouths projecting to form the little black dots referred to above. In these receptacles a second spore form is developed consisting of large, opaque black or dark brown, boat-shaped ascospores, arranged in groups of eight in thin cells or asci. This is the only stage observed in Nyasaland and it is probable that most of the cases of this disease observed in the young tea came from infection by means of these ascospores, which were abundant in the specimens collected on forest and shade trees. Further investigations may show that the typical spreading patches so commonly caused by this fungus in Ceylon around *Grevillea* stumps also occur in Mlanje and, therefore, the control measures described below are designed to meet this possibility.

CONTROL MEASURES AGAINST ARMILLARIA AND USTULINA.

Both the root diseases caused by *Armillaria mellea* and *Ustulina Zonata* are amenable to a considerable measure of control on somewhat similar lines, especially if steps to prevent their appearance in new clearings are adopted. For this purpose it is scarcely necessary, in the restricted Mlanje area, to attempt to distinguish one from another. The main points to be borne in mind are that both are favoured in their earlier stages by the presence of rotting wood in large masses in the soil and that their spread is chiefly underground.

It is not safe to clear forest land for tea planting in the Mlanje area without stumping. The two fungi are present throughout the district and no estate is free from them. Both seem to be equally capable of starting from rotting tree stumps in the soil, for in no other way can the isolated

spreading patches of disease round such stumps be explained. *Armillaria* is evidently also able to extend from the still standing forest into adjoining tea, and *Ustulina* is liable to infect pruning cuts and other wounds by spores, though this is not common except, perhaps, in young tea. The value of stumping is recognized in the district, and not only is most of the newly cleared land being stumped but buried stumps are being dug out in some gardens from the planted-out tea. It is obviously better to remove them before the tea is planted, and this is the first and most essential measure in attempting to secure freedom from root disease. Fortunately, most of the forest consists of small trees and it is only in certain places that large *Khaya* and other trees are found. Some of these might, perhaps, better be dealt with by isolating them by a trench than by digging them out, the large surface laterals being cut through and removed.

In spite of these precautions root disease may appear and a careful watch must be kept to detect any attacks in an early stage. As soon as a bush dies it should be removed and adjoining bushes examined to see if they show signs of attack. Very often several bushes near together are affected almost simultaneously. When this occurs or when a definite patch has appeared, trenching to prevent the underground spread of the fungi should be at once resorted to. No other method can replace trenching as a control measure in small patches. The trench should be three feet deep and should surround the patch and one row of apparently healthy bushes, for it is obvious that the latter may be so recently infected as to show no symptoms above ground, and failure to isolate them will make the trenching useless. The soil from the trench should be thrown into the patch, not outside. Then the dead bushes should be removed, the apparently healthy ones examined on the side towards the patch and also removed if signs of infection are seen, and the whole patch dug over to a depth of at least two-and-a-half feet, all fragments of roots being removed as far as possible. The bushes and pieces of root should be piled and burnt in the patch, or if too damp to burn, should be scorched with straw or dried prunings and left until dry enough to burn. If the removal of diseased bushes is done after plucking has finished, say, in April, a second digging over should be done about October. If the work is carefully done it may be safe to supply in the following rains, say in January or February, using large, strongly-rooted seedlings for the purpose. If experience shows that such supplies are liable to contract infection it will be necessary to postpone supplying until the following rains. Supplying earlier than nine or ten months after removing infected roots is unsafe, and tests may show that even this period is insufficient to rid the soil of infection. When a single bush dies, trenching is unnecessary if the soil be well dug over after the bush is removed, and the roots of bushes in contact with it are examined. In this case a great deal will depend on whether the bush can be removed immediately it shows clear signs of root disease. If labour requirements force it to be left for some months, neighbouring bushes are likely to be infected and must also be removed. In all cases an attempt should be made to discover whether the attack has come from a rotting tree stump, and this should be removed when located.

When the disease has progressed unchecked for a number of years the patches become so irregular and extensive that trenching may be impracticable. More than one affected garden was seen in which it would be almost impossible to devise any system of trenches that would effectively preserve the still healthy bushes. In such cases reliance must be placed on the removal of affected bushes and thorough digging of the soil so as to leave as few roots in it as possible.

Liming the soil after removing the bushes is usually recommended, its main object being to promote the rapid decomposition of fragments of roots in which the fungus may be living. Where lime is cheap and easily available, so that heavy doses can be given, it is worth using, but it cannot replace thorough cultivation, whereas the latter can replace liming. There is little doubt that the more thorough and deeper the cultivation the less favourable the soil becomes for the two fungi under consideration, and the thorough turning over of the soil two or three times after removing infected roots should be effective in freeing it from them.

When the tea abuts on the forest a deep trench should be dug separating one from the other, in order to prevent continual reinfection from the latter by *Armillaria mellea*. A watch should also be kept on shade and avenue trees, and all cases of death from root disease treated in the same way as in the tea itself. It is exceedingly unwise to pile the stumps of uprooted or fallen trees in the neighbourhood of the tea as is sometimes done, owing to the tendency for ripe fructifications of *Ustulina zonata* to develop on them. If they cannot be removed they should be scorched, since fructifications were not found on the stems of scorched trees.

The above are the chief direct methods of fighting the root diseases caused by these two fungi. They are based on the fact that buried stumps and diseased tea roots are the common sources of infection. Land that is habitually kept free from decaying wood, such as ordinary plough land, does not usually contain these fungi. Trenching would be unnecessary could all diseased roots and other decaying wood be removed to a depth of say three feet, and it is being discouraged in Assam in favour of the latter procedure. But it is not always convenient to provide the necessary labour for thorough digging over when the first cases are seen, and the isolation of the patch by trenching after removing the larger roots may prevent undue spread until the ground can be thoroughly dug over. Indirect methods of prevention calculated to improve the vigour of the bushes so as to enable them to resist attack will be dealt with later, as they are applicable to all the types of root disease encountered.

INTERNAL ROOT DISEASE CAUSED BY BOTRYODIPLODIA THEOBROMAE.

The fungus for which the name *Botryodiplodia Theobromae* is still used, though it is extremely doubtful whether it is the correct one, is a common species in the tropics, where it is found in forest and grass land as well as in arable soils. Its parasitism has been proved in the case of certain host plants, such as cacao, sugar-cane, and *Hevea* rubber and there is little doubt that it can also attack tea, on which the disease attributed to it is known as internal root disease in Ceylon and India. In many cases, however, it is found on roots and stems after they have been injured by some other agency, and its presence on dead tea roots is by no means evidence that it caused their death. In Africa it is responsible for a die back and pod disease of cacao in the Gold Coast and Uganda and it is associated with a root disease of apple trees in Kenya.

In India young tea is said to be most frequently attacked on cleared grass land and in coarse sandy soils, but elsewhere it has not been possible to associate the disease with any particular type of land. It is commonest in old tea in the low country of Ceylon, but has also been observed on young bushes and at higher altitudes. The attack usually develops only after pruning and it may increase progressively from the first cutting back given after planting out through several successive prunings until as many as 50 per cent. of the bushes are affected. Though it is not so common as the diseases caused by *Ustulina* and some other tea root parasites, it is said to be capable of killing a greater number of bushes in each individual outbreak than any other root disease.

The attack becomes visible six weeks to three months after pruning, the pruned bush sometimes failing to put out any new shoots and being rapidly killed. When new shoots grow, they may remain healthy until they are six or eight inches long and then die back. In other cases single branches may die or the bush may remain moribund for a long time. In the early stages the leaves of affected bushes or parts of bushes become mottled with pale-yellow or yellowish green patches. Then they turn black at the tips and along the edges and fall prematurely. The roots appear to be clean and healthy until they are cut, when the wood is found stained pale bluish-black. The colour is due to an internal mycelium of stout, smoky-black hyphae which give off finer hyaline branches. There is no external mycelium and no visible accumulation of hyphae into sheets and strands between the layers of the bark. On examining the roots with a lens, especially after death, slightly prominent, round black bodies of small size, which are the fructifications of the fungus, may be detected almost buried in the bark. Frequently, however, they are not visible until the surface of the bark is shaved away, when they appear as small black circles with a white centre. Various other fungi found on dead tea roots in Nyasaland have a somewhat similar appearance, so that it is safer to rely on the characteristic bluish-black or slate-coloured staining of the wood for a diagnosis. The fructifications are spherical spore receptacles (pycnidia), sometimes united into clusters in a stromatic mass of black mycelium, and they contain large, oval spores which, when ripe, are uniseptate and dark brown, though they are white in the mass and unseptate when young. In the early stages the mycelium may be found only in the finer roots, but direct attack on the tap root also occurs. Later on the dark mycelium may rapidly penetrate all parts of the root system as well as the base of the stem.

A further, perfect, spore-form of this fungus has been described under the name *Thyridaria tarda,* but is not generally accepted. More recently it has been suggested that the perfect stage is *Physalospora rhodina,* but this has not yet been found associated with the tropical forms of the fungus.

The patches caused by this disease may be very large, and in Ceylon may develop around the stumps of *Albizzia moluccana* trees that have been ringed or cut down when they have grown too large. The fungus develops on such stumps and produces spores in abundance, which infect the surrounding tea. The same tree grown as coffee shade has also proved liable to attack in Uganda. Infection by spores often takes place through wounds in the larger roots caused by cultivation and also in stems as a result of pruning. Observations indicate that they usually do not succeed unless the wood has been dried out after pruning. A more frequent source of internal root disease is probably the accumulation of buried prunings in the soil, as the fungus grows and sporulates freely on such prunings and patches have been observed to start around the holes in which they had been buried.

Cases of the root disease caused by this fungus were not common in Nyasaland, except in young tea, during the period of my visit. Mature dead bushes were never found to have more than an occasional root infected, and no patches of dying bushes suffering from internal root disease were seen. The only instances in which bushes appeared to have been killed by *Botryodiplodia Theobromae* were in the first or second year after planting out, and such attacks were always sporadic. They were sometimes associated with the presence of *Ustulina,* so that it was impossible to decide which was the primary cause of death. I was informed, however, by Captain Smee, the Entomologist to the Nyasaland Department of Agriculture, that

during the dry period of the year the fungus is present on the roots of many dead bushes, and it is clear that much further investigation is required before its relative importance as a cause of tea root disease in Nyasaland can be determined.

This fungus is a weak parasite, especially in the underground parts of plants, and is one of those that can best be fought by improving the general health of the bushes. There is no evidence that it is able to infect tea by the growth of mycelium from buried stumps, so that stumping has no influence on its attacks, except in so far as the wood of decaying stems and roots of such trees as *Albizzia* may serve as a reservoir from which spores are discharged into the surrounding tea. It has been noticed in India that there are few spores discharged in the earlier weeks after the cessation of the rains, and it is recommended that when heavy pruning is required in tea on areas where the disease is prevalent, it should be done during this period, and at the same time two or three ounces of nitrate of potash should be applied around each bush in order to stimulate the new growth. In such land, also, prunings should never be buried but should be collected into heaps and burnt. There is some indication in the Mlanje district that young tea is more liable to be attacked when planted on cleared grass land, as in northern India, and in such areas at least the prunings should be burnt, not buried.

THE SCLEROTIAL ROOT DISEASE CAUSED BY MACROPHOMINA PHASEOLI (RHIZOCTONIA BATATICOLA.)

This fungus has only been recorded on tea in Ceylon, where it was first reported in August, 1926, though the question of its parasitism on this host was left open pending further study. Previously it has been investigated in some detail as a parasite of various plants in India, the United States, Egypt, and Uganda, and in 1927 there arose a considerable controversy as to its importance as a cause of root disease of woody plants in Ceylon. In India it attacks cotton, jute, groundnuts and cowpea and has been found on many other plants; in the United States, sweet potatoes, ordinary potatoes, and beans; in Egypt, cotton, cowpeas, and beans; and in Uganda, some forty different plants, including coffee (on which it is reported to cause a serious root disease), cacao, eucalyptus, and a number of woody plants used as shade or green manure in tea and coffee plantations. In Kenya also it is one of the causes of coffee root disease. In Ceylon the number of its hosts appears to be at least as large as in Uganda (including a high proportion of the economically valuable plants of the Colony) and it is evidently one of the most nearly omnivorous parasites known. It appears to be confined to warm countries, its distribution corresponding roughly to the areas in which cotton can be grown.

In Nyasaland *Rhizoctonia bataticola* is associated with a disease of tea seedlings still in the nurseries, and it was also found sporadically on the roots of dead bushes about a year after planting out and, less often, on those of mature bushes.

The seedling disease was severe in only a few beds in one nursery, though a number of individual attacks occurred in several other nurseries involving both newly imported and acclimatized seed. The leaves of affected seedlings turn pale and then wither and fall off more or less completely. The shoot dies back to the collar, but usually new shoots arise at or below the surface of the ground and the plants often recover. On pulling up plants after the leaves have withered, a wet patch of partially rotted bark is found extending along the taproot and base of the stem for about half an inch at the seed

level (one to two inches below the surface of the soil). This rot usually involves the seed (which may be reduced to a slimy mass probably by the action of secondary organisms), but it does not ordinarily penetrate into the woody tissues of the seedling, and in those that recover little signs of its presence are found. The lateral roots are clean and apparently quite free from this fungus. The surface of the rotting bark in all cases examined bore moderately stout, brown hyphae of the type characteristic of *Rhizoctonia,* and the small black sclerotia that distinguish *Rhizoctonia bataticola* were found in a few roots when the bark was peeled off, though they are by no means universally present. In cotton seedlings also it is not easy to find sclerotia, and the cause of the cotton seedling disease due to this fungus, which is common in India, is often difficult to determine without cultural work. The most severely affected seedbeds were in the lowest part of a nursery, these particular beds being bounded on two sides by tall grass which kept the air moist and stagnant.

Typical sclerotia of *Rhizoctonia bataticola* were found on the taproot of two bushes which had died about a year after planting out, and from one of these a pure culture of the fungus was obtained. A very large proportion of the young tea had died in the field from which these were obtained, a field which had been recently cleared from the same belt of forest as that which gave rise to the most severe attack of *Armillaria mellea* mentioned above. In none of the other cases examined, however, could the cause of death be determined, and it is possible that the field was affected by the disease next to be described.

The only case seen in which a mature bush had apparently been killed by *Rhizoctonia bataticola* was a single dead bush surrounded by healthy tea. It had dried up completely and the tissues, especially those of the roots, were bleached, hardened, and unusually light. The collar showed no signs of fungus attack, but a considerable number of the lateral roots, from one-eighth to half an inch thick, contained numerous hyphae and characteristic sclerotia in the inner bark and outer layers of the wood. No other parasite was found, and the death of the bush may be attributed with considerable probability to *Rhizoctonia bataticola.* In another case a bush was seen with a dead branch at one side arising from near the ground level and sclerotia of the fungus were found on two roots just below this point. On various other occasions roots of diseased bushes were found with a growth of *Rhizoctonia bataticola* usually in the neighbourhood of wounds inflicted during cultivation or otherwise, but other tea root parasites were present and may have been responsible for the diseased condition.

Tea roots affected by this fungus show little external symptoms; indeed, as a rule, none that can be detected without the use of a good lens, except the condition described above as found on the taproot of diseased seedlings. In older plants the cortex of affected roots is brittle and its inner layers may show a tendency to shredding, coming away from the wood as a bundle of fibres rather than a single continuous sheet. In the inner layers or, more often, on the surface of the wood very small, rounded or elongated, black dots can often be seen with the lens. Microscopic examination shows that these are composed of thick-walled, brown cells forming small stromatic bodies or sclerotia. The mycelium is generally scanty and is composed of hyaline hyphae, very variable in diameter and with the branching characteristics of *Rhizoctonia.* The older hyphae may turn brown and at the same time show a tendency to form clusters of the dark-walled cells. The sclerotia usually appear as the tissues dry up, and the manner of their formation has been fully described by Shaw and Small. They are amongst the smallest known, averaging not much more than 100 microns in diameter.

Under certain conditions, which appear to be difficult to reproduce artificially, this fungus gives rise to a sporing form which was originally described on bean stems from Tunis under the name *Macrophoma Phaseoli*. This form has since been obtained on several of the hosts of the sclerotial form from Formosa, the Philippines, India, Uganda, Ceylon, and the West Indies and the most recent study, in which full literature references and synonymy are given, indicates that the correct name for the organism is *Macrophomina Phaseoli* (Maubl.) Ashby. On one of the young tea bushes that had died soon after planting out, a pycnidial form agreeing fairly well with *M. Phaseoli* developed near soil level in material brought to England, so that it is probable that the sporing stage of the fungus also occurs on tea. This stage on other plants consists of small black spore cases (pycnidia), smaller and more superficial than those of *Botryodiplodia* and containing a number of colourless, unseptate, elongated spores, measuring about 16 to 30 by 6 to 9 microns in diameter. On tea, however, the spores were only 16 to 22 by 4.5 to 6 microns, which is unusually small for *M. Phaseoli* so that it is not certain that they belonged to the *Rhizoctonia* parasite or that they play any part in the dissemination of the disease.

The accounts of the mycelial characters of this fungus are so discrepant that it is difficult to believe that they all relate to the same fungus. On woody plants in Uganda it is described as forming black crusts and plates on and in the bark, and wavy black lines on the wood and bark of affected roots. Unfortunately, in both East Africa and Ceylon most of the plants on which *M. Phaseoli* has been found, including tea, are liable to infection by various other fungi, which often co-exist with the sclerotial fungus. So common, indeed, is this association that Dr. Small holds the *Rhizoctonia* to be the primary parasite in all these root diseases of woody plants, the others being secondary followers that at most hasten the destruction of the roots. That the mycelium of some of these has been at times confused with the growth of *M. Phaseoli* is clear from the mention, both by Shaw and Small, of clamp-connections in the hyphae, pycnidial fungi being devoid of such organs, and it is possible that the crusts and black lines are equally due to mixed infection. Black lines are common in tea roots in Nyasaland on which sclerotia are found, but the latter are so frequently present without any trace of black-line formation that I doubt the connection between the two. In an attempt to distinguish between the black lines formed by *Armillaria mellea* and *Ustulina zonata*, specimens of the former on beech wood from Scotland (where the latter is unknown) and of the latter on rubber from Malaya (where *Armillaria* has not been reported) were compared and were found to be identical. This indicates the impossibility of determining from the characters of the lines in the wood the organism by which they were formed, and it must, for the present, be regarded as doubtful whether *Rhizoctonia* is capable of causing black lines in tea roots. [Preparations of *Rhizoctonia* lines were sent to Dr. Butler from Ceylon and information was received in May 1928 to the effect that he was satisfied that *Rhizoctonia bataticola* could develop distinctive black lines in wood in Ceylon.—*Ed., T.A.*]

Besides the typical minute sclerotia, pure cultures isolated from which agreed with those of *M. Phaseoli* from various sources grown at the Imperial Bureau of Mycology, other more irregular, often more prominent and shiny, and usually somewhat larger sclerotioid bodies were not uncommonly found on the dead roots and collars of bushes of all ages. Some of these appeared to be associated with pycnidial fungi other than *Macrophomina*. As cultures from these small stromata were not obtained, it was not possible to determine their identity.

Fungi of the genus *Rhizoctonia* are well-known as amongst the causes of damping-off in seedbeds, and the tea seedling disease above mentioned may be included in this category. They are favoured by overcrowding, insufficient ventilation, and excessive moisture. The tea seedling disease associated with *Rhizoctonia bataticola* is, so far as my observations went, usually not severe enough to justify special measures for its control. Where it is found attacking a considerable number of the seedlings, watering should be reduced and if the bed is shaded the coverings should be raised so as to allow the air free access to the beds. It might be advisable to remove them completely at night. The beds should not be sited in localities where there is not a reasonably free circulation of air, and tall grass or the like should be cut down in their immediate vicinity.

Seedlings that have died back in the manner described should not be used for planting out, even when they subsequently put out new shoots, as it is highly probable that the presence of the fungus on older plants is in part due to mycelium and sclerotia transferred with the plants from the seedbed.

Attacks on older bushes cannot be prevented by any practicable measures, but they appear to be so sporadic as to be of little importance. It is a safe rule to remove all dead bushes when noticed in order to prevent the accumulation of root fungi in the tissues and their subsequent dissemination into the soil.

One other *Rhizoctonia* infection of considerable interest was found on a seedling that had died a year or two after planting out. The roots were covered with a violet growth in long twining strands or thin sheets. This was the mycelium of a fungus agreeing in all essentials with the well-known *Rhizoctonia crocorum,* the cause of the violet root rot of many plants in temperate countries and occasionally in the tropics. However, as *R. crocorum* has recently been shown to be the sterile stage of *Helicobasidium purpureum,* whereas an allied but distinct species, *H. longisporum,* is known on the roots of cacao and rubber in Uganda, it is possible that this *Rhizoctonia* belongs to the latter fungus. There was little doubt that the bush had been killed by its attack, but only one case of the kind was seen and the disease appears to be of no importance at present.

AN OBSCURE TEA DISEASE.

Reports received indicated that the most serious root disease of tea in Nyasaland was that attributed to *Botryodiplodia Theobromae,* and it was soon evident that a large proportion of the patches of unhealthy or dead tea in the estates visited had many of the characteristics of internal root disease.

These patches were very irregular in shape, and whether they started from a single or several foci of infection, they nearly always showed several areas near together in which all or most of the bushes had died, while between these many of the bushes were healthy. The bare areas were connected with one another by alleys or lines of bushes which were dead or unhealthy, and beyond the limits of the patches single cases, apparently representing advance infections which often missed the nearer bushes to attack those further away, were found. The attack may commence in any part of a garden, except in the clay hollows ("dambos") previously mentioned, and though, in time, a great part of the garden may appear sickly, the advance is always roughly centrifugal and the parts furthest from the original attack are the last to become affected.

This disease appears to be responsible for more injury than all those previously mentioned taken together. It was the only disease causing spreading patches seen in the Cholo area and was the cause of exceedingly

grave losses in some Mlanje estates. When of several years' standing, the total number of bushes affected in each attack ran into hundreds, and supplying with healthy seedlings had not checked the losses since the new plants were often attacked in their turn.

The above-ground symptoms are somewhat similar to those described in the internal root rot of tea first seen by me in Assam in 1902 and of which a short account was published in Watt and Mann's "Pests and Blights of the Tea Plant," 2nd Ed., pp. 414-416, 1903. The first sign is the development of shoots bearing small, narrow, pale-green leaves, often with their edges upturned. The pale colour is due to a slight yellowing of the intervenous parts of the leaf blade, the veins remaining a darker green colour so that they show up prominently, just as in the Assam disease. As these shoots are not plucked, the bush soon assumes a twiggy appearance. In spreading patches these symptoms may develop on one side only, usually that from which the patch is advancing, but the side attacked does not die quickly as in unilateral infection by *Armillaria mellea* or *Ustulina zonata*, being marked, during the first rainy season at least, only by the pale narrow leaves and thin twiggy growth of the affected parts. In the following dry season these twigs may die back, but in the next rains a new growth of thin branches with few and still smaller leaves may partly replace them, while the rest of the bush develops the early symptoms of attack. In the second dry season most of the branches may die, but the rains again lead to the development of a few leafy shoots. The third dry season may see the bush killed, though it appears probable that several years often elapse before death takes place. This course is much slower than that of the other diseases described above except internal root disease, though the spread of infection from bush to bush is at least as quick, with the result that a considerable area may appear yellow and sickly even when the patches of dead bushes are of small size.

In certain areas the disease was said to be associated with the previous presence of particular trees, the commonest being *Parinarium mobola*. In one case seen nearly all the bare patches where bushes had been killed were situated so as each to encircle one of some half a dozen isolated, large, living *Albizzia fastigiata* trees, but the bushes between these were mostly in various stages of the disease and many were dead or dying.

In the early stage of attack the roots appear to be free from any fungous parasite. A complete examination of the root system from the collar to the finer feeding roots was carried out in several typical cases in the first year of the disease and nothing whatever was found that would explain their condition. The bark appears smooth and it and the wood are full of sap. They separate from one another unusually readily, appear to be more succulent, and the wood cuts more easily than in normal plants. The cells of the inner cortex and outer layers of the wood of the medium and smaller roots are often filled with a gummy substance together with flakes of a harder material. In the fleshy feeding roots the usual internal mycorrhiza of tea (the type with vesicles and arbuscules) is richly developed and the inner tissues are obviously healthy and functioning normally, but the surface of these roots and of those next in order may be irregular and roughened as if sucked or irritated by nematodes or something of the kind. A few roots were found, as might be expected, to contain occasional hyphae, but these were not always of the same type and were altogether too few to account for a serious disease. Numerous attempted isolations from the roots gave quite inconclusive results, yielding no one fungus consistently and in some cases nothing at all. *Botryodiplodia Theobromae* was only once found in a single root, in these early cases, and it is impossible to attribute the disease to its attacks, though Captain Smee informed me that it is common

on bushes that have died in the manner described (which is very like certain cases attributed to this fungus) during the hot dry period of the year. Bushes killed by, or in the last stages of, this disease that I examined showed various fungi in their roots including *Botryodiplodia,* but their general absence in the earlier stages makes it impossible to regard them as its cause.

The disease is locally regarded as a root disease and it is difficult to avoid this conclusion in view of the obviously spreading nature of the affected areas and their reported association with the previous presence of certain forest trees. Except for its unusually irregular spread, it has all the characters of a progressive underground infection by a parasitic fungus, though none such was found. The only other disease that I am acquainted with that spreads in a somewhat similar way and that apparently is not a root disease is the spike disease of sandal (*Santalum album*) in southern India, and this belongs to the most obscure group of the so-called virus diseases, a group of which peach yellows in the United States is the best known example. Though the upcurling of the leaf margins in affected tea bushes and their mottling with pale and darker green suggests a virus disease, I am not aware of any that spreads so gradually and continuously; the leaf mottling is only due to retention of colour by the veins longer than the rest of the leaf, being thus unlike that found in the mosaic diseases; and there is no accumulation of starch as in peach yellows and spike disease of sandal.

Virus diseases, with a few exceptions, are ordinarily transmitted from plant to plant by insects. The exceptions include tobacco mosaic, where human agency is probably responsible for most of the spread, and, perhaps peach yellows and sandal spike, where the method of transmission is unknown. In a few instances, the chief of which is raspberry mosaic, the insect vector may be so sluggish that spread is continuous from plant to plant mainly by passive dissemination of the insect (as by means of the wind or by persons passing through the bushes and conveying green fly from one to another on their clothing). Some such method of spread must be responsible if the tea disease here described is due to an insect-borne virus.

In the absence of knowledge of the cause of this disease, it is difficult to suggest methods of control. Observations indicate that it is worst in gardens where the soil has been exposed to wash or where the bushes are enfeebled from any other cause. The general measures for the indirect control of root diseases by improving the vigour of the bushes discussed below should, therefore, have an effect in reducing the losses caused by this disease. In advanced cases it is hopeless to attempt to save the bushes, and they should be removed and the patches treated as recommended for *Armillaria mellea* and *Ustulina zonata.* Whether earlier removal (as soon as the first symptoms are observed) should be recommended is doubtful on present knowledge. Experiments should be carried out in new extensions to test the effect of thorough roguing (eradication of every diseased bush at an early stage) on the spread of the disease, but such experiments should be under expert supervision if they are to yield reliable results. Stumping has been advised on account of the other diseases, and the reported association of this disease with certain tree stumps may indicate that this measure may be useful also against it.

There are many instances of successful control of a plant disease, the cause of which is unknown. Most of them are based on observations regarding the incidence and spread of the disease. Such information is very scanty in the present instance and requiries to be supplemented by careful

observation, pending an opportunity for more detailed research into the case of trouble. It is not unlikely that the disease occurs in the East but has been confused with the effects of *Botryodiplodia Theobromae,* and it is hoped that the above description may call the attention of pathologists in other tea-growing countries to what is unquestionably one of the most serious diseases to which the tea bush is liable.

GENERAL RECOMMENDATIONS FOR IMPROVING ROOT DEVELOPMENT.

These should be directed primarily to checking soil wash, improving drainage, and maintaining soil fertility or restoring it when depleted.

The soils of the Mlanje tea area lend themselves particularly well to the checking of wash by the use of blind contour drains, the soil from which is thrown up along the upper face of the drain to make a low ridge which catches much of the silt and in time helps to form level terraces. Catch drains of this type were seen easily to hold the water in a fall of nearly nine inches in 24 hours, percolation in the open Mlanje soils being sufficient to prevent the drains from filling. In this case the slope was relatively gentle and the vertical distance between the drains was about 3½ feet. The various types of silt pits and terraces that may be used to check erosion are fully discussed by Captain Hornby in the Bulletin already referred to, and the details of their construction are outside my scope.

Cover cropping is the second main method of checking wish, and the extended use of cover crops in the Mlanje tea gardens, especially where there is little shade, would probably have a beneficial result. Little experimenting has been done in Nyasaland with cover crops suitable for tea, but many have been tested in Ceylon, and some of those that have proved satisfactory there, especially species like *Indigofera endecaphylla,* belonging to genera common in the country, would probably be equally so under Nyasaland conditions. The period of the year when the cover is most required is December, as the first heavy rains, while the soil is bare after the hot weather and before the weeds have grown, do the greatest damage.

Green manuring and deeper cultivation have a twofold effect, in that they not only improve fertility but increase the water absorbing and holding capacity of the soil and thus check wash due to the run-off of the surface water. A good many green manures have been tested, but there appears still to be room for the introduction of low-growing leguminous crops that will keep down weeds, cover the soil well, and not impede the growth of the bushes. The "mposa" bean *(Phaseolus mungo)* was the most nearly satisfactory in this respect of those seen actually in use in the tea. In most gardens, however, green manuring is not practised, and its extended employment is probably one of the best methods of improving the surface development of the roots.

Drainage is well known to improve root development and to lessen susceptibility to disease. The extended range of the root system in well drained soils helps the plant to resist drought conditions and to survive the loss of the surface roots from whatever cause, unless the taproot or collar of the bush becomes involved. Drainage and cultivation are the two main factors that render soil unsuitable for the growth of such forest fungi as *Armillaria mellea* and *Ustulina zonata,* and their neglect is probably the chief reason for the persistence of these parasites in gardens that have been cleared from forest for many years.

Fertilisers have been little used in Mlanje tea, under the mistaken belief that the soils are sufficiently rich to make them unnecessary. Whatever chemical analyses may show, there is sufficient evidence that the surface soils are, in general, in need of improvement, and in a great many gardens the use of fertilisers is clearly indicated. Phosphatic fertilisers combined with green manuring have a well-known effect in increasing surface root development and thus improving the health of the bushes. The Nyasaland Department of Agriculture is in a position to advise on the most suitable fertilisers for the different types of soil. In some of the gardens that have suffered most severely from soil wash there is no doubt that the restoration of fertility will be an exceedingly difficult task and will require to be carried out on the lines adopted for the renovation of old, worn-out tea soils in the East.

These matters have been touched on only in their bearing on the incidence of root diseases in the tea. Attention to them is at least as important as any direct methods of combating these diseases, such as stumping, trenching, and the removal of dead bushes. All the diseases encountered are present throughout the district, and the difference in their severity depends in great part on the manner in which the vigour of the bushes has been maintained. Neighbouring gardens may be seen, in one of which the losses from disease are relatively slight because the health of the bushes has been maintained by checking wash, fertilising, and good soil and bush management, while in the other the condition of the tea has become so serious that it is doubtful whether it can be renovated without an almost prohibitive expenditure. There is probably no estate in the district which would not become as bad as the worst now visible in respect of root diseases if neglected, but, on the other hand, there are few that cannot be brought back into good condition by methods directed to remove the causes of ill-health discussed above.

STEM AND BRANCH CANKER (? MACROPHOMA THEAE SPESCHNEW)

The stem canker or die back associated with the presence of the fungus *Macrophoma theae* is the only disease of consequence found on the above-ground parts of the bush in Nyasaland. It was first observed in February or March, 1926, when it caused much damage by killing back the shoots of the older bushes and leading to the death or serious injury of young plants and nursery seedlings. The attack was worst in hollows where the soil is moist and badly drained, and it was reported by Mr. E. W. Davy, Assistant Director of Agriculture (from whom the first specimens of the disease were received at the Imperial Bureau of Mycology), that there was no doubt that plants raised from imported Indian seed were far less resistant to the stem canker than those from acclimatized Mlanje seed. Mr. Davy reported that Captain Smee had found a *Macrophoma* very commonly on the cankered areas, and the latter stated subsequently that this fungus was also found on *Grevillea* trees in the affected areas.

Isolations made from Mr. Davy's specimens yielded chiefly a species of *Macrophoma*, differing from *M. theicola* Petch, the cause of a stem canker in Ceylon, but agreeing in measurements with *M. theae*, which Speschnew described as the agent of a leaf spot of tea in the Caucasus. A species of *Tubercularia*, resembling that belonging to the *Nectria* that causes die back of tea in northern India, was also present on some of the branches. Cultures of both these fungi were taken to Nyasaland in order to attempt to produce the disease by inoculation.

During my visit this disease was little in evidence, no doubt as a result of the drastic treatment carried out during the previous year. One affected garden of young tea, however, had not been heavily pruned to eradicate the cankers, and in this a number of cases were seen. The affected bushes each had one or more withering branches with yellowed or falling leaves. When these branches were more closely examined they were found to show swollen cankerous areas involving sometimes a considerable length of stem, sometimes only the neighbourhood of the lateral branches or the bases of the latter. The thickening surrounds the entire stem, as a rule, and its surface is marked by a longitudinal cracking of the bark, which is often detached in flakes. Through the cracks there may be a protrusion of reddish woody tissue, which forms irregular cushions so that the swelling is not of uniform thickness all round the stem. At the time of my visit (February-March) true cankers exposing the original wood were rare, the infection having evidently not progressed very far, but in the material collected by Mr. Davy the previous July typical cankers were not uncommon. When the shoot is entirely ringed and the bark is destroyed down to the wood, the branch dies back above the point of attack, and this die back of the shoots is the main symptom later in the year. The cankers are less regular in appearance than those caused in Ceylon by *M. theicola*, the callus ring surrounding them is less uniform and less prominent, and they are often partially covered by shreds of bark. They are, however, exceedingly like one of the forms of branch canker known on tea in India without any clue having, as yet, been found as to its cause. Infection appears to take place just below the insertion of the lateral branches (possibly through the leaf scar) and to extend usually both up and down the main stem and also out along the lateral branch. The longer cankered areas are usually caused by the union of several distinct infections. The surface of the cankered area may show the small black pycnidia of *M. theae* or, less often, the light pink cushions of the *Tubercularia*. Other fungi are also found, but only one of these belongs to a genus (*Pestalozzia*) known to cause tumours or cankers, and as the species agreed with the common tea parasite *P. theae*, which is not capable, so far as is known, of producing similar effects, it was not further considered.

The structure of the thickened stem tissues is of considerable interest. The greater part of the increased diameter is due to the formation of gall wood on the inside of the cambium. A much smaller increase takes place in the layers external to the latter, phloem and cortex. At a certain moment in the growth in thickness of the shoot, the cambium is stimulated to an excessive activity and commences to form on its inner face cells differing in their subsequent development from the normal elements of the wood. The new tissue thus formed is, therefore, heteroplastic, in Küster's sense of the word. There is an increased production of parenchyma, the medullary rays are broader and less sharply defined, and the wood fibres and vessels may be few at first, as compared with the normal wood. The result is a kataplasmatic gall, the bulk of the new tissue being gall wood. At the same time, there is a slight increase in the tissues external to the cambium; these may become twice as thick as the normal bark, but the growth pressure exercised by the expanding gall wood causes splitting of the outer bark and the formation of irregular cork layers deeper in, so that finally there may be little cortex left. The expanding medullary rays may sometimes be traced across the cambium into the phloem, and in the latter, as well as in the deeper part of the cortex, stone cells and cells containing large crystals, almost entirely filling them, are developed.

Sometimes the cambium is killed and the overlying cortex dies, the resulting wound being covered more or less completely by an overlapping growth of the gall wood and of tissues exterior to the latter.

If only a small part of the cambium dies, and the surrounding tissues are growing rapidly, a fissure entirely closed in may be formed in a part of the ring between the normal and the gall wood. In severer injuries, and especially at a later period of the year, the wound remains as a gaping canker with swollen callus lips around it. No alteration ever seems to take place in the original woody cylinder until open cankers lead to its decay, and the pith of the stem is also unaltered in appearance.

As a result of the irregular growth of the gall wood, especially where fissures are produced, its elements do not pursue a regular radial course. The medullary rays and other radially disposed elements in the normal wood become laterally displaced or curved, and may even eventually lie transversely to the radial axis. A curious feature observed in some of the galls is that while the cells nearer the sound wood are mostly parenchymatous and relatively little differentiated, though with strongly pitted or reticulated walls, those further out, near the cambium (and, therefore, the most recently formed), resemble normal wood with clearly differentiated fibres and vessels. In such cases it would appear that the stimulus that causes the development of the gall wood acts only for a time.

Colourless hyphae occur in a few of the outer layers of the gall wood and in the phloem, in other words immediately on both sides of the cambium. In young galls, sections taken near the limit of the thickened part may show no hyphae, even though the ring of gall wood is already clearly defined. In some galls no hyphae were seen until nearly a quarter of an inch behind the part of the stem in which the new wood could first be distinguished. This suggests that the stimulus leading to the formation of gall wood acts beyond the limit of the area occupied by the fungus. The hyphae found at the advancing edge of the infection were large "exploratory" hyphae, running longitudinally in the outermost vessels, further back, more numerous, smaller hyphae occur in the outer vessels, the neighbouring parenchyma, and the phloem tissues. They are always hyaline, intracellular, predominantly longitudinal in direction (except in the medullary rays), and sparingly branched. Sometimes even in fairly early stages, similar hyphae can be found in the outermost vessels of the normal wood internal to the gall wood. At this period, however, hyphae were not found in any other part, the pith, the cortex, and all the normal and gall wood except the regions above specified being quite free from infection. In older material, however, the mycelium spreads throughout all the tissues and is readily found from the cortex inwards to the pith.

There is little doubt that this mycelium is the cause of the disease. Its distribution, corresponding so exactly with the tissue stimulated to abnormal activity, and its constant presence a short distance behind the advancing limit of the stem thickening, tell strongly in favour of a causal connection. It is less certain that this mycelium is that of *Macrophoma theae*. It has not been found possible to trace a direct union between the internal mycelium and the external pycnidia, and the single series of inoculation experiments undertaken with pure cultures failed, as did the similar ones made with the *Tubercularia*. A single failure, of course, is not conclusive, as there is no exact knowledge of the part of the stem through which entry is normally effected (leaf scar and wound inoculations on young branches were tried) nor of the season of the year at which the disease starts (the inoculations were made on 24th March, by which time the disease had already been in evidence for some months). It appears probable, on the

whole, that *M. theae* is the cause of the disease, not only because it was the fungus most commonly isolated from the cankers but also because *M. theicola* is already known to cause a somewhat similar disease while *M. tumefaciens* forms tumours which are highly suggestive of a stimulatory action like that described above. In culture the mycelium of *M. theae* would pass sufficiently for that present in the galls, except that with age the hyphae become brown and brittle. In old cultures, too, the spores eventually become brown and septate, resembling those of the genus *Hendersonia*. Speschnew's fungus was found only on the leaves, and there are several cases in which species identified as *Macrophoma* have subsequently been found to develop septate spores when old, so that this fact by itself does not invalidate the identification of the Nyasaland fungus with the Caucasian one.

When the stem canker first appeared, Mr. Davy advised cutting the affected nursery seedlings back to three inches of stump, i.e., well below the cankered area, followed by heavy spraying with Bordeaux mixture and a subsequent lighter spraying when new growth commenced. On the young, recently planted out tea he recommended hard pruning, with spraying, and thorough draining of the affected areas. In older gardens pruning out diseased branches was considered to be sufficient, accompanied by manuring. Further recommendations from the Bureau of Mycology included measures intended to promote improved root development and the application of potash. In affected nurseries attention has been drawn by Captain Smee to the necessity of improving soil conditions and, especially, the ventilation of the seedlings by opening up the vegetation surrounding the nursery site.

As already stated these measures, which were vigorously applied, appear to have been completely effective. In the absence of more exact knowledge of the life-history of the organism responsible for the disease they appear to be all that can be recommended.

MEETINGS, CONFERENCES, ETC.

BOARD OF AGRICULTURE.

ESTATES PRODUCTS COMMITTEE.

Minutes of the forty-second meeting of the Estates Products Committee of the Board of Agriculture held at the head office of the Department of Agriculture at 11 a.m. on Tuesday, March 12th, 1929.

Present:—The Acting Director of Agriculture (*Chairman*), the Government Entomologist, the Government Agricultural Chemist, the Organising Secretary, Rubber Research Scheme, Gate Mudaliyar A. E. Rajapakse, Dr. C. A. Hewavitarne, Major J. W. Oldfield, Messrs. R. G. Coombe, J. Horsfall, A. T. Sydney-Smith, I. L. Cameron, A. W. Ruxton, J. Sheridan-Patterson, E. F. Home, C. A. M. de Silva, G. R. de Zoysa, C. E. A. Dias, Wace de Niese, N. D. S. Silva, J. E. P. Rajapakse, J. D. Dunlop, C. C. Du Pré Moore and T. H. Holland (*Secretary*).

Visitors:—Lt.-Col. T. Y. Wright, Messrs. L. A. Wright, J. W. Ferguson, H. Wilkinson, E. E. Megget, J. Ferguson, F. P. Jepson, H. L. Roch and G. Harbord.

AGENDA ITEM 1.—CONFIRMATION OF MINUTES.

The minutes of the last meeting which had been circulated to members were taken as read and were confirmed.

AGENDA ITEM 2.—CO-OPTATION OF MEMBERS.

Mr. C. D. Sparkes was co-opted as a member of the committee in place of Mr. D. S. Cameron who had resigned.

AGENDA ITEM 3.—PROGRESS REPORT OF THE EXPERIMENT STATION, PERADENIYA, FOR THE MONTHS OF JANUARY AND FEBRUARY, 1929.

Mr. Holland briefly reviewed this report.

Mr. Sheridan-Patterson, referring to the cutting down of rubber stumps in nurseries, enquired in what month the stumps had been cut down.

Mr. Holland replied that they had been cut down at the end of September.

Mr. Coombe enquired if scrapers were still used for weeding tea.

Mr. Holland replied that it was so; the tools which had been sent by Mr. Coombe were used on the Iriyagama Division.

Dr. Hewavitarne enquired if more tea supplies had died during the recent drought under shade than in unshaded plots.

Mr. Holland replied that greater losses had been sustained in an unshaded plot but that losses had also occurred in plots shaded with both dadap and *Gliricidia*.

AGENDA ITEM 4.—MODIFICATION OF PROPOSALS FOR THE PLANTING OF THE IRIYAGAMA DIVISION OF THE EXPERIMENT STATION, PERADENIYA.

The recommendatons of the sub-committee appointed to consider these plans had been circulated to members. The Chairman read the recommendations clause by clause and invited comment.

Mr. A. W. Ruxton proposed that the report of the sub-committee should be adopted. This was seconded by Mr. G. R. de Zoysa and carried.

AGENDA ITEM 5.—DRAINS AND TERRACES ON THE IRIYAGAMA DIVISION OF THE EXPERIMENT STATION, PERADENIYA.

The Chairman explained the position. After the resolution which had been passed at the previous meeting he and Mr. Holland had considered the matter. They had suggested as a compromise that where level drains were dug continuous terraces should be cut, but where drains of a gradient of 1 in 40 had been dug individual terraces should be cut for each tree. Both Mr. Dias and Mr. Ruxton had agreed to this compromise and he now put to the meeting the question of revising the decision made at the last meeting.

Mr. C. E. A. Dias proposed and Mr. A. W. Ruxton seconded that the arrangement explained by the Chairman should be accepted. This was carried.

AGENDA ITEM 6.—SEED GARDENS.

Copies of a form of advertisement asking for land for this purpose had been circulated to members. The Chairman asked for criticism of or suggestions on the draft.

Mr. Coombe suggested that the advertisement should be sent to Planters' Associations in rubber districts.

Mr. Wace de Niese suggested that it might be done through Planters' Associations without advertising in the press.

It was finally resolved that the advertisement should be sent to all Associations likely to be interested, as well as to the principal daily papers and *The Tropical Agriculturist.*

At this stage the Chairman referred to a list of budded plants growing at the Kegalle Experiment Station and a key to the list which was laid on the table. He explained the connection between the key and the list.

AGENDA ITEM 7.—REPRESENTATION OF RESEARCH SCHEMES ON THE ESTATES PRODUCTS COMMITTEE.

Mr. R. G. Coombe spoke on behalf of Mr. George Brown who was unable to be present. He read a letter from Mr. Brown. Mr. Coombe said that, speaking on behalf of the Tea Research Institute, he was most anxious for all possible co-operation with the Department of Agriculture.

The Chairman said that he had discussed the matter with Mr. Brown and suggested that it was not necessary that all the scientific officers of all the research institutions should be co-opted as members of the committee but that the directors or chief scientific officers of the institutions should be members and that it should be left to them to arrange which of their officers should attend any particular meeting. He did not think Mr. Brown was in favour of this view. He explained that the Organising Secretary of the Rubber Research Scheme was already a member of the Estates Products Committee.

Mr. Coombe endorsed the Chairman's view, and thought that Mr. Brown would agree.

Mr. Sydney-Smith agreed with the Chairman's suggestion. He thought it unnecessary that all officers should attend every meeting.

Major J. W. Oldfield suggested co-opting the chief scientific officer of each institution or his nominee.

The following resolution was finally proposed by Mr. R. G. Coombe, seconded by Mr. A. T. Sydney-Smith, and carried:

"That the Estates Products Committee take steps to co-opt the chief scientific officers or their nominees of each of the research institutions, viz. the Tea Research Institute, the Rubber Research Scheme, and the Coconut Research Scheme, when the last-named comes into being."

AGENDA ITEM 8.—PARIS GREEN TREATMENT OF TERMITES OF TEA.

The Chairman said that since the report of Mr. Jepson's visit to America had been put before the committee, important results had been obtained regarding the efficiency of Paris Green treatment and regarding the danger of the presence of arsenic in the flush.

Mr. Jepson said that when his report had been submitted the committee had decided that Government should be asked to defer publication of it until it had been shown by analytical work that there was no danger of the presence of arsenic in the flush of treated bushes. Experiments had been in progress for eight months and he now desired to report progress and to obtain sanction for the publication of this original report. He explained the object of the experiments. A considerable measure of success had been obtained and he thought that 100 per cent. mortality could be assured. He had been fortunate in obtaining the assistance of the Government Analyst, Mr. Symons. Samples of flush had been regularly sent to Mr. Symons and no trace of arsenic had been found. Also, up to date, no ill effects on the bushes had been noted. The treatment appeared so promising that he considered it could now be applied on estates and that the report should be published. He wished to make acknowledgment of the help he had received from Mr. L. A. Wright who had treated 6,000 bushes on Brunswick Estate, Maskeliya, and had supplied all the samples for analysis. Mr. Jepson explained the method of treatment and emphasised the fact that the treatment had been safely carried out on Brunswick Estate.

After discussion which was taken part in by Messrs. Sydney-Smith, Wright, Ruxton, and Mr. Jepson, Mr. R. G. Coombe proposed that Mr. Jepson's report should be published. The proposal was seconded by Mr. Ruxton and was carried, nine members voting for it and two against it.

Mr. G. R. de Zoysa enquired regarding the cost of the treatment. Mr. Jepson thought the cost would prove to be less than 1 cent per bush. Mr. L. A. Wright hoped to be able to supply more accurate figures at a later date.

T. H. HOLLAND,
Secretary,
Estates Products Committee.

DEPARTMENTAL NOTES.

WORK ON SELECTION OF RUBBER. SEED GARDENS.

FOR the purpose of carrying on the above work plots of land in which budded rubber may be planted are required in order to found isolated seed gardens. The number of plots required is forty. The size of each plot should be one acre, and the plots must be situated a distance of at least one mile from the nearest rubber and from each other. The land should not be steep or rocky or swampy, and it should be easily accessible.

It is necessary that security of tenure for at least ten years be assured, and, while the co-operation of lessors in the provision of labour is desirable, it is not intended that the lessors should be put to expense or should be asked to make themselves pecuniarily responsible for the planting or cultivation or upkeep of the plots. The plants grown in the plots and their products such as budwood and seed will be the sole property of the Department of Agriculture or other body that may be in charge of the work.

The work of the seed gardens may prove of great importance and be of benefit to the whole rubber industry of Ceylon, and it is hoped that offers of land sufficient to make forty seed gardens will be forthcoming. Offerers are requested to communicate with the undersigned and to intimate the terms on which they are willing to lease one-acre plots.

W. SMALL,
Acting Director of Agriculture.

SCHOOL GARDEN COMPETITION IN KANDY AND MATALE DISTRICTS.

A school garden competition for the cultivation of medicinal herbs was held in the Kandy and Matale districts for prizes of Rs. 60·00 and Rs. 40·00 offered by Mudaliyar W. Daniel Fernando Waidyasekera, of Panadura.

2. Several gardens entered the competition and the following have been adjudged winners of prizes.

KANDY DISTRICT.

Alawatugoda b.
Nugawela b.
Teldeniya b.

MATALE DISTRICT.

Tenne b.
Kuriwela m.

REVIEW.

DISEASES OF ANIMALS IN TROPICAL COUNTRIES.*

THE authors have endeavoured to furnish in popular language a description of the diseases of animals in tropical countries. The book is intended for the use of students in agricultural colleges and for those in charge of live stock. It can be thoroughly recommended for these purposes. The descriptions of symptoms are very lucid and should enable the breeder to recognise serious illness at an early stage and to apply appropriate preventive measures pending the arrival of professional aid.

In the section on strongylosis of ruminants it is surprising to find no mention of *Mecistocirrus digitatus*, the commonest species in Ceylon and the cause of heavy mortality in calves and young stock.

In the chapter on tick fever of cattle it might have been made clearer that the classical symptoms described are seldom seen in native cattle born and bred in an area where the disease is enzootic, but are quickly developed, frequently with fatal results, when cattle are imported into such areas from areas where the disease does not exist. This is a fact which must always be borne in mind when schemes for breeding improved stock are contemplated in the tropics.

Horse owners in Ceylon will be disappointed to find no mention of osteoporosis, the most serious disease of horses in this country.—M. Crawford, M.R.C.V.S.

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* *Diseases of Animals in Tropical Countries* by C. R. Edmonds and G. R. Walker, 2nd edition, London: Bailliere, Tindall & Cox, 1929. Shill. 25.

ANIMAL DISEASE RETURN FOR THE MONTH ENDED 31st MARCH, 1929.

Province, &c.	Disease	No. of Cases up to date since Jan. 1st, 1929	Fresh Cases	Recoveries	Deaths	Balance Ill	No. Shot
Western	Rinderpest	1133	435	126	894	39	74
	Foot-and-mouth disease	10	...	10	...	...	...
	Anthrax	...	...	...	...	...	...
	Piroplasmosis	1	...	...	1	...	...
	Rabies*. (Dogs)						
Colombo Municipality	Rinderpest	1200	186	98	1060	42	...
	Foot-and-mouth disease	5	4	5	..	...	...
	Anthrax	...	..	...	...	...	...
	Rabies (Dogs)	12	2	...	...	...	12
Cattle Quarantine Station	Rinderpest	44	...	27	17	...	...
	Foot-and-mouth disease	14	7	14	...	...	...
	Anthrax	...	...	...	...	...	...
Central	Rinderpest	46	3	1	44	...	1
	Foot-and-mouth disease	673	262	400	2	271	...
	Anthrax	...	...	...	...	...	...
	Rabies (Dogs)	7	...	...	...	...	7
	Black Quarter						
Southern	Rinderpest	...	.	...	...	...	...
	Foot-and-mouth disease	2013	1226	1905	56	52	...
	Anthrax	...	...	..	...	...	...
Northern	Rinderpest	4	...	3	...	...	1
	Foot-and-mouth disease	157	7	80	70	7	...
	Anthrax	...	...	...	...	...	...
Eastern	Rinderpest	...	..	...	...	...	...
	Foot-and-mouth disease	8006	. .	7851	155	...	...
	Anthrax	...	...	...	...	...	...
	Rabies (Horses)						
North-Western	Rinderpest	101	78	7	47	4	43
	Foot-and-mouth disease	...	...	...	...	...	..
	Anthrax	...	...	...	..	...	...
	Piroplasmosis	1	...	1	...	—	...
North-Central	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	26	...	26	...	...	...
	Anthrax	...	...	...	...	...	...
Uva	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	303	...	278	1	23	1
	Anthrax	...	...	...	...	...	...
	Haemorrhagic Septicaemia	1	1	...	1	...	...
Sabaragamuwa	Rinderpest	125	67	26	92	6	1
	Foot-and-mouth disease	4148	851	3739	78	331	...
	Anthrax	—	...	...	...	...	...
	Haemorrhagic Septicaemia	10	3	...	10	...	...

G. V. S. Office,
Colombo, 11th April, 1929.

G. W. STURGESS,
Government Veterinary Surgeon.

METEOROLOGICAL

MARCH, 1929.

Station	Temperature		Mean Humidity	Mean amount of Cloud 0=clear 10=overcast	Mean Wind Direction During Month	Daily Mean Velocity	Rainfall		
	Mean Daily Shade	Difference from Average					Amount	No. of Rainy Days	Difference from Average
	°	°	%			Miles	Inches		Inches
Colombo Observatory	80·3	—0·3	80	5·2	Var.	93	6·69	13	+1·96
Puttalam	81·4	+0·8	76	4·0	NNE	110	1·02	8	—1·99
Mannar	82·8	+0·5	72	4·3	NNE	190	1·51	3	+0·02
Jaffna	81·5	—0·6	74	4·1	E	109	0	0	—1·20
Trincomalee	80·8	+0·1	79	4·2	ENE	126	2·13	11	+0·38
Batticaloa	80·0	—0·8	84	5·0	NNE	175	2·66	12	—0·53
Hambantota	81·0	+0·6	78	4·2	E	242	4·51	14	+2·02
Galle	81·0	—0·1	78	5·6	Var.	108	5·08	10	+0·41
Ratnapura	82·2	0	74	4·8	—	—	5·31	22	—3·92
Anu'pura	80·8	—1·1	64	5·6	—	—	3·91	9	+1·05
Kurunegala	82·6	—0·2	70	6·6	—	—	4·22	10	—1·04
Kandy	78·1	—0·3	72	5·3	—	—	4·78	11	+0·71
Badulla	73·6	+0·6	82	7·6	—	—	9·09	16	+4·49
Diyatalawa	67·2	0	80	5·6	—	—	4·94	18	+0·62
Hakgala	62·2	—0·2	82	5·4	—	—	8·32	15	+2·80
N.'Eliya	58·9	—0·3	78	6·0	—	—	6·02	15	+2·53

The majority of stations in the south-west of the Island, and in the hill-country, registered falls for the month of between 5 and 10 inches. There were a few heavier falls, chiefly near the lower slopes of the hills, while further north the rainfall figures fell off, no station in the Jaffna Peninsula reporting more than 2 inches, and Jaffna town, Kankesanturai, Vadamarachchi, and Delft reporting no rain at all for the month. The rain was mainly due to local thunderstorms, and excesses above average were very irregularly distributed.

Hail was reported on the 26th at Lindula, and on the 28th at Panwila, near Kandy.

Temperatures were generally near their average. The mean humidity varied from 64 at Anuradhapura to 84 at Batticaloa. Cloud and wind were both generally above normal, the wind being generally north-easterly. Heavy wind, presumably a whirlwind, caused considerable damage on the outskirts of Colombo, near Cotta, on the 7th.

H. JAMESON,
Actg. Supdt., Observatory.